GEORGIA INSTITUTE OF TECHNOLOGY — OFFICE OF CONTRACT ADMINISTRATION

PROJECT ADMINISTRATION DATA SHEET

[X] ORIGINAL [ ] REVISION NO. ____

Project No. G-35-620 (GTRI)/GIT DATE 12-9-82

Project Director: Dr. L. T. Long School/Lab Geo-Sci

Sponsor: U.S. Dept. of the Interior
U.S. Geological Survey

Type Agreement: Contract No. 14-08-0001-21241

Award Period: From 12-1-82 To 11-30-83 (Performance) 2-28-84 (Reports)

Sponsor Amount: Total Estimated: $ 31,860 Funded: $ 8,000 (thru 22883)

Cost Sharing Amount: $ n/A Cost Sharing No: —

Title: Seismic Monitoring of the Richard B. Russell Dam Impoundment

ADMINISTRATIVE DATA — OCA Contact Frank Huff X4820

1) Sponsor Technical Contact: (2 copies)

Karen Ward
U.S Dept. of the Interior
Geological Survey
~~Address~~
345 Middlefield Road MS 85
Menlo Park, California 94025
(415) 323-8111 X 2764

2) Sponsor Admin/Contractual Matters: (1 copy)

Mary Russell, Contracting Officer
U.S. Dept. of the Interior
Procurement & Contracts Section
Administrative Division
345 Middlefield Road
Menlo Park, California 94025
(415) 323-8111 x 2107

Defense Priority Rating: —

Military Security Classification: NONE

(or) Company/Industrial Proprietary: ____

RESTRICTIONS

See Attached Gov't Supplemental Information Sheet for Additional Requirements.

Travel: Foreign travel must have prior approval — Contact OCA in each case. Domestic travel requires sponsor approval where total will exceed greater of $500 or 125% of approved proposal budget category.

Equipment: Title vests with Gov't over $1000; under $1000 vests with GIT

COMMENTS:

COPIES TO:

Research Administrative Network	~~Research Security Services~~	Research Communications (2)
Research Property Management	Reports Coordinator (OCA)	Project File
Accounting	GTRI	Other P.D
Procurement/EES Supply Services	Library	Other

GEORGIA INSTITUTE OF TECHNOLOGY OFFICE OF CONTRACT ADMINISTRATION

SPONSORED PROJECT TERMINATION/CLOSEOUT SHEET

2-428 5

Date 12/18/84

Project No. G-35-620 School ~~AXXX~~ Geo. Sci.

Includes Subproject No.(s)

Project Director(s) Dr. L. T. Long GTRC / ~~GXX~~

Sponsor U. S. Dept. of the Interior

Title Seismic Monitoring of the Richard B. Russell Dam Improvement

Effective Completion Date: 11/30/83 (Performance) 2/28/84 (Reports)

Grant/Contract Closeout Actions Remaining:

- [ ] None
- [X] Final Invoice or Final Fiscal Report
- [X] Closing Documents
- [X] Final Report of Inventions – already received
- [X] Govt. Property Inventory & Related Certificate
- [ ] Classified Material Certificate
- [ ] Other

Continues Project No. Continued by Project No.

COPIES TO:

Project Director
Research Administrative Network
Research Property Management
Accounting
Procurement/EES Supply Services
~~Research Security Services~~
Reports Coordinator (OCA)
Legal Services

Library
GTRI
Research Communications (2)
Project File
Other A. Jones; M. Heyser

Form OCA 60:1028

Georgia Institute of Technology
A UNIT OF THE UNIVERSITY SYSTEM OF GEORGIA
ATLANTA, GEORGIA 30332
SCHOOL OF GEOPHYSICAL SCIENCES
404/894-3893

10 May 1983

Ms. Karen Ward, COR
Procurement and Contracts Section
U.S.Geological Survey
345 Middlefield Road, M/S 85
Menlo Park, CA 94025

Subject: Quarterly Management Report No.1 covering period of December 1, 1982 to February 28, 1983

Date Submitted: May 10, 1983

Research Title: Seismic Monitoring of the Richard B. Russell Dam Impoundment

Contract Number: 14-08-0001-21241

Contractor: Georgia Tech Research Institute
Atlanta, GA 30332

Contract Period: December 1, 1982 - November 30, 1983

Amount: $31,860.00

Principal Investigator: Leland Timothy Long

Dear Ms. Ward:

One objective of the first quarter was to continue to analyze the spectral estimates of data acquired from the Monticello Reservoir, South Carolina. A second objective was to augment our capability to monitor induced seismicity behind the Richard B. Russell dam by increasing the number of seismic stations available for possible recording and by developing a high-frequency, rapid deployment, prototype recording array.

1. Major Accomplishments: We have continued to evaluate the influence of depth-of-focus on spectral slope above the corner frequency. The data consisted of 51 events recorded at close range on digital event recorders at Monticello Reservoir, South Carolina. First motions were used to determine angle of incidence and spectra were computed from trace displacement in the direction of propagation. The events studied show no variation with depth of the high-frequency slope. The lack of variation may be a consequence of the narrow depth

range of the data. Changes in corner frequency and high-frequency slope were positively correlated which may indicate that earthquakes with smaller fault planes have fewer asperities on the fault plane.

The repair and updating of three permanent seismic stations for the Richard B. Russell dam was begun. To date, 80% of the components have been acquired and 35% of the required repairs have been completed.

The development of five high-frequency, rapid deployment, prototype seismic recorders was started. The evaluation of commercially available analog recorders is 80% complete. So far, none of the recorders are acceptable for direct recording of an amplified seismic signal. Research of alternative inexpensive recording schemes is in progress.

2. Problems Encountered: No problems other than those expected.

3. Fiscal Status: Out of $31,860.00 total funds available, $1,780.85 were expended at the end of the first quarter. The available funds are sufficient to complete the task.

4. Action Required by USGS: No action is requested or required at this time.

5. Future Plans: 1) The study of the influence of depth of focus on a seismic spectral discriminant will be continued on data obtained from the Monticello Reservoir, South Carolina, as part of a student's thesis. 2) For the preparations of the three additional seismic stations in the Richard B. Russell area, we will acquire the remaining compenents and will repair the seismometers, and assemble the three stations in easily installed casings. We have located suitable field sites for these three should they be necessary to install. The development of the five portable tape units is progressing well. 3) We will evaluate a design improvement which would utilize triggered recording and commercial analog delay units. The signal would be recorded with a time signal on a slow-speed tape recorder. For the purpose of timing we will evaluate the following: commercial RF stations, WWVB, and 70 KHz local transmitters. 4) In coordination with a project for the Corps of Engineers, the RF telemetry system has been designed. The paper work and purchasing required for 3 stations has been completed and can be repeated quickly for possible installation of the three USGS supported stations in the Reservoir area.

6. Inventory of Property Acquired During Report Period: No property was acquired during the report period.

Respectfully submitted,

Leland Timothy Long
Professor of Geophysics

LTL:dg:pr

Georgia Institute of Technology
A UNIT OF THE UNIVERSITY SYSTEM OF GEORGIA
ATLANTA, GEORGIA 30332
SCHOOL OF GEOPHYSICAL SCIENCES 404/894-3893

1 August 1983

Ms. Karen Ward, COR
Procurement and Contracts Section
U.S.Geological Survey
345 Middlefield Road, M/S 85
Menlo Park, CA 94025

Subject:	Quarterly Management Report No. 2 covering period of March 1, 1983, to May 31, 1983
Date Submitted:	August 1, 1983
Research Title:	Seismic Monitoring of the Richard B. Russell Dam Impoundment
Contract Number:	14-08-0001-21241
Contractor:	Georgia Tech Research Institute, Atlanta, GA 30332
Contract Period:	December 1, 1982 - November 30, 1983
Amount:	$31,860.00
Principal Investigator:	Leland Timothy Long

Dear Ms. Ward:

One objective of the second quarter was to expand the analysis of spectral estimates of data acquired from the Monticello Reservoir, South Carolina, to include data from Mammoth Lakes, California. A second objective was to continue to augment our capability to monitor induced seismicity behind Richard B. Russell dam. This includes increasing the number of seismic stations for possible recording and continuing the development of a high-frequency, rapid deployment, prototype recording array.

1. Major Accomplishments: The influence of depth-of-focus on spectral slope above the corner frequency has been evaluated for earthquakes in the vicinity of Monticello Reservoir, South Carolina, and Mammoth Lakes, California. The data, which was obtained from the USGS, was recorded on three-component digital event recorders and includes 70 events near the Monticello Reservoir and 30 events near Mammoth Lakes. First motions were used to determine angle of incidence, and spectra

were computed from trace displacement in the direction of propagation. As mentioned in the previous quarterly report, the spectra of the events occurring near the Monticello Reservoir showed no variability of high-frequency slope with depth which may have been a consequence of the narrow depth range of the data. However, the events recorded near Mammoth Lakes occurred over a much wider range of depth, and there is evidence that the spectral slope decreases with increasing focal depth.

The repair and updating of three additional permanent seismic stations for deployment in the vicinity of the Richard B. Russell dam is progressing. To date, 95% of the components have been acquired and 60% of the required repairs have been completed.

The installation of phone lines and microwave telemetry for the existing stations is 90% complete.

The development of five high-frequency, rapid deployment, prototype seismic recorders is progressing. The evaluation of commercially available analog recorders is complete. One such recorder which can be modified to our specifications has been found. We have obtained and tested the seismometers. A prototype seismometer amplifier which includes a 6 volt to ± 6 volt converter has been tested and is now working. The voltage converter is an addition to our original design and will allow operation on a single power supply. Of the timing methods tested, we have found that an A.M. radio clear channel is best.

2. Problems Encountered: No problems other than those expected.

3. Fiscal Status: Out of $31,860.00 total funds available, $7,701.86 were expended at the end of the second quarter. The available funds are sufficient to complete the task.

4. Action Required by USGS: No action is requested or required at this time.

5. Future Plans: 1) The study of the results of the influence of depth of focus on a spectral discriminant will be continued. 2) We will continue to evaluate a design improvement which would utilize triggered recording and commercial analog delay units. 3) Field testing of the five portable seismic recorders will begin the first week of September. 4) We will reinstall a seismic station (CHF) close to the dam site so that it can provide coverage to the east and south of existing stations.

6. Inventory of Property Acquired During Report Period: No property was acquired during the report period.

Respectfully submitted,

Leland Timothy Long
Professor of Geophysics

Georgia Institute of Technology
A UNIT OF THE UNIVERSITY SYSTEM OF GEORGIA
ATLANTA, GEORGIA 30332
SCHOOL OF GEOPHYSICAL SCIENCES
404/894-3893

2 November 1983

Ms. Karen Ward, COR
Procurement and Contracts Section
U.S.Geological Survey
345 Middlefield Road, M/S 85
Menlo Park, CA 94025

Subject:	Quarterly Management Report No. 3 covering period of June 1, 1983, to August 31, 1983
Date Submitted:	October 15, 1983
Research Title:	Seismic Monitoring of the Richard B. Russell Dam Impoundment
Contract Number:	14-08-0001-21241
Contractor:	Georgia Tech Research Institute, Atlanta, GA 30332
Contract Period:	December 1, 1982 - November 30, 1983
Amount:	$31,860.00
Principal Investigator:	Leland Timothy Long

Dear Ms. Ward:

One objective of the third quarter was to expand the analysis of spectral estimates of data acquired from the Monticello Reservoir, South Carolina, and Mammoth Lakes, California. A second objective was to continue to augment our capability to monitor induced seismicity behind Richard B. Russell dam. This includes increasing the number of seismic stations available for siting in the reservoir area and the development of a high-frequency, rapid deployment, prototype recording array. A third objective was to assist in publishing a quarterly seismicity bulletin.

1. Major Accomplishments: We have found a distinct relation between depth-of-focus and the spectral slope above the corner frequency for earthquakes in the vicinity of Mammoth Lakes, California. To strengthen this conclusion we have performed other tests on the data and refined the analysis techniques. For S-waves we have re-computed the spectra for a trace component perpendicular to

the propagation path direction and found no significant difference from spectra computed from the trace component in the direction of propagation. We attribute this to the dominance of scattered phases in the coda. We have also added additional events in order to try to estimate the depth range.

No additional progress was made in the repair and updating of three additional permanent seismic stations for deployment in the vicinity of the Richard B. Russell dam. Instead, our efforts were directed to the conversion of the three stations to RF telemetry.

The design for the high-frequency, rapid deployment recorders is complete and the first unit is under construction. All components have been tested and components for a total of six units have been ordered. The design is flexible enough to accommodate either conversion to triggered recording of a delayed signal or use of frequency modulated recording. Initially the timing will employ individual WWV recievers.

2. Problems Encountered: One technical problem encountered is to determine whether the slope versus depth relation holds for all earthquakes or only earthquakes with a tectonic mechanism that can be related to the mechanisms for reservoir induced seismicity. The summer months were difficult because of a lack of personnel. However, we expect to be able to catch up fall quarter with new personnel.

3. Fiscal Status: Out of $31,860.00 total funds available, $18,534 were expended at the end of the third quarter. The available funds are sufficient to complete the task.

4. Action Required by USGS: No action is requested or required at this time.

5. Future Plans: 1) The study of the spectral source theory will be extended to try to explain our observations at Mammoth. Much of this work will be part of a master's thesis. As necessary, additional data will be analyzed. 2) The portable tape units will be constructed during the fourth quarter and we will investigate triggered delay units as an alternate option. 3) Field testing of the tape units will be done in early November 1983. 4) Station CHF will be reinstalled late October 1983 as a single component vertical.

6. Inventory of Property Acquired During Report Period: No property was acquired during the report period.

Respectfully submitted.

Leland Timothy Long
Professor of Geophysics

LTL:pr/lm

Georgia Institute of Technology
A UNIT OF THE UNIVERSITY SYSTEM OF GEORGIA
ATLANTA, GEORGIA 30332
SCHOOL OF GEOPHYSICAL SCIENCES
404/894-3893

8 May 1984

Ms. Karen Ward, COR
Procurement and Contracts Section
U.S.Geological Survey
345 Middlefield Road, M/S 85
Menlo Park, CA 94025

Subject:	Quarterly Management Report No. 4 covering period of September 1, 1983, to November 30, 1983
Date Submitted:	May 8, 1984
Research Title:	Seismic Monitoring of the Richard B. Russell Dam Impoundment
Contract Number:	14-08-0001-21241
Contractor:	Georgia Tech Research Institute, Atlanta, GA 30332
Contract Period:	December 1, 1982 - November 30, 1983
Amount:	$31,860.00
Principal Investigator:	Leland Timothy Long

Dear Ms. Ward:

One objective of the final quarter was to analyze the spectral estimates of earthquake data acquired from the Monticello Reservoir, South Carolina, and Mammoth Lakes, California. A second objective was to continue to augment our capability to monitor induced seismicity behind Richard B. Russell dam. This includes increasing the number of seismic stations available for siting in the reservoir area and the development of a high-frequency, rapid deployment, prototype recording array. A third objective was to assist in publishing a quarterly seismicity bulletin.

1. Major Accomplishments: The data from Monticello Reservoir earthquakes show no observable relationship between source depth and the high-frequency slope. We attribute this to the narrow range in depth for the available earthquakes. The events at Mammoth Lakes occur over a large depth range, and the high-frequency slopes of the earthquake

spectra decrease with increased source depth. The combined P-wave data for Mammoth Lakes and Monticello Reservoir reveal a trend for the distribution of high-frequency slopes to change from higher values at shallower depths to lower values at greater depths. However, this trend was not obvious in the shear-wave data. The higher corner frequencies were often associated with steeper slopes above the corner frequency, indicating that the number of fault plane barriers is related to the fault dimension. The analysis of the data on Mammoth Lakes and Monticello Reservoir has been compiled as a M.S. Thesis by Jeffrey Kent Wilson titled "Influence of focal depth on the displacement spectra of earthquakes".

Station CHF was reinstalled as a short-period single component-vertical seismometer and is in operation. Its site is moved approximately 2000 ft from its previous location. However, seismic noise from the water released at the base of the Richard B. Russell Dam is significant and limits the effectiveness of the station to large local events except when the gates are closed. The three other stations--BEV, LDV, and IVA--have been converted to RF telemetry to the vicinity of CHF where they are mixed for transmission over a single, less expensive line to Georgia Tech. The three additional stations are on hold at about 60% completion awaiting evidence of induced seismicity.

The high-frequency, rapid deployment recorders have all been assembled. We were able to find parts for eight (two more than planned). Two have been calibrated and tested by simulating input signals similar to local earthquakes. They were also field tested, but no events occurred during the test period.

2. Problems Encountered: The relations among the data analyzed for this project are complex and a complete theoretical justification and evaluation was not performed. While we were careful with the technique, some ambiguity inherent in spectral estimates remains. The effects of scattering of the seismic waves were pronounced, and a correct method for isolating scattering effects from source effects was not resolved.

We had hoped to be able to field test the tape units in the R. B. Russell Reservoir and report the results for this project, since the filling was scheduled to begin in December and January. Unusual rains filled the reservoir rapidly to within 2 m of full pool in January 1984. However, as of May 8, 1984, the reservoir has stubbornly refused to exhibit any seismicity. I consider this behavior abnormal and discourteous.

3. Fiscal Status: Out of $31,860.00 total funds available, $31,500.46 were expended at the end of the fourth quarter and $409 encumbered.

4. Action Required by USGS: The USGS is requested to be patient and to direct a few small earthquakes to the R. B. Russell Reservoir.

5. Future Plans: 1) We will continue to try to explain the results by a comparison with published source theory relevant to shallow earthquake sources. 2) If events are triggered in the R. B. Russell Reservoir area, we will test the tape recorders. Otherwise, resources permitting, we may try them out in the Monticello Reservoir area, although a study of that area might not give clues as to the initiation of the process of reservoir induced seismicity. 3) We will be attempting to explain why no events were triggered in the Richard B. Russell area.

6. Inventory of Property Acquired During Report Period: No property was acquired during the report period.

Respectfully submitted,

Leland Timothy Long
Professor of Geophysics

LTL:pr[ltl3]

GEORGIA INSTITUTE OF TECHNOLOGY

QUARTERLY EARTHQUAKE BULLETIN

1 December 1982 - 28 February 1983

By

Leland Timothy Long, Anton M. Dainty, Jeffrey K. Wilson,

Anthony P. Johnson, Jeih-San Liow, Robert M. Duckworth, and An Tie

School of Geophysical Sciences

Earth Sciences Division

Supported by:

Alabama Geological Survey
(through contract with U.S. Nuclear Regulatory Commission)

Georgia Power Company

U.S. Army Corps of Engineers
(Savannah District)

U.S. Geological Survey
(Contract No. 14-08-0001-21241)

Tennessee Valley Authority

U.S. Army Corps of Engineers
(Mobile District)

QUARTERLY EARTHQUAKE BULLETIN

1 December 1982 - 28 February 1983

The information presented in this bulletin includes the origin times, magnitudes, hypocentral coordinates and their precision, and the arrival times of selected phases for local earthquakes recorded by seismic stations maintained by Georgia Tech, School of Geophysical Sciences.

The network consists of 23 seismic stations located in Alabama, southeast Tennessee, Georgia, and South Carolina monitored by the School of Geophysical Sciences at Georgia Tech. Additional seismogram readings were obtained from stations operated by the Tennessee Valley Authority and the Tennessee Earthquake Information Center. The coordinates of the stations used in locating the events are given in Table 1. A map of the seismic stations maintained by Georgia Tech is given in Figure 1. Bollinger and Mathena (1983) describe the instrumentation of the seismic network and magnitude threshold.

The events are located using a computer program with techniques similar to those used in HYPO71 but is more flexible in assigning weights and utilizing phases.

Magnitudes are defined by their duration according to the equation:

$$m_b(Lg)_{Dur} = -1.7 + 2.21 \log_{10} T ,$$

where T is the mean signal duration in seconds (Chaplin, Taylor, and Toksöz, 1980). A map showing the epicenters can be seen in Figure 2 and is followed by data sheets containing information and individual events that occurred during the quarter.

References

Bollinger, G. A., and E. Mathena (1983). Seismicity of the southeastern United States, Southeastern U.S. Network Bulletin, 11, May 1983.

Chaplin, M. P., S. R. Taylor, and M. N. Toksöz (1980). A coda-length magnitude scale for New England, Earthquake Notes, 51, No. 4, 15-22.

Table 1. Coordinates of stations used in locating the events in this report.

STA	Latitude	Longitude
BBG	34.8740	83.8110
BEN	35.5660	81.6611
BEV	34.0893	82.7334
BHT	35.8470	84.9450
CBT	35.5394	84.4206
CH5	33.7332	82.3118
CH6	33.8938	82.5291
CRG	34.6589	84.5821
DCT	35.0542	84.4194
ETT	35.3260	84.4550
HGA	34.2602	85.8464
HPK	35.9260	83.8790
IVA	34.2721	82.7460
LDV	34.1479	82.6833
OCA	34.6138	86.4352
RCT	35.3453	84.6614
RHT	35.0781	84.8825
TDA	33.5417	86.0247
TLT	35.3011	84.2833
TKL	35.6581	83.7742
TSA	33.2561	87.0675
TVG	34.3771	85.3023

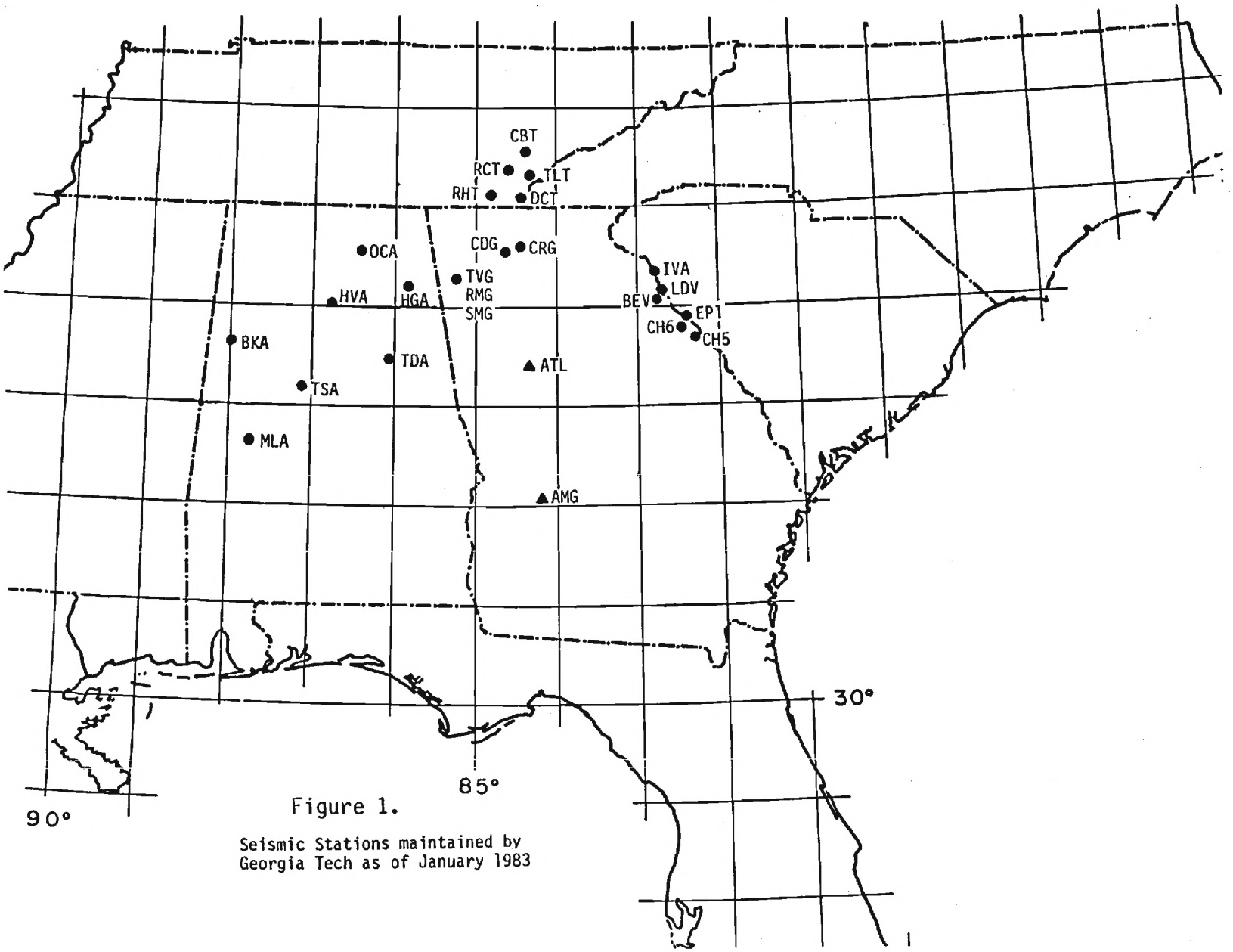

Figure 1.

Seismic Stations maintained by
Georgia Tech as of January 1983

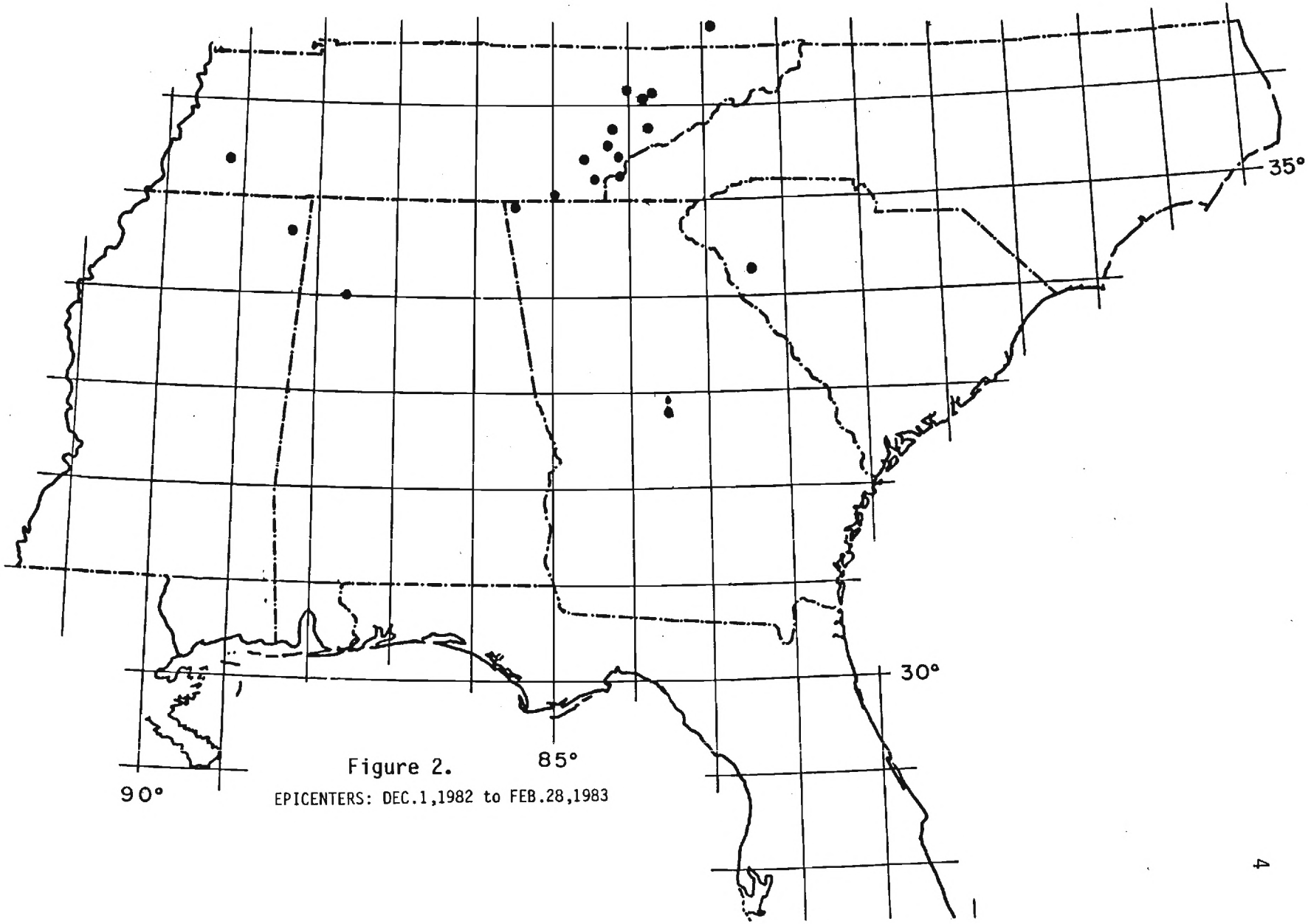

Figure 2.

EPICENTERS: DEC.1,1982 to FEB.28,1983

THE EVENT OCCURED ON DEC 1, 1982
AT ORIGIN TIME 3: 6:23.69 +/- .533
TENN
MAGNITUDE: 2.0
THE WEIGHTS ARE
WX= 1.000 WY= 1.000 WZ= 0.000 WT= 1.000
IT WAS LOCATED AT
LATITUDE 35.7754 +/- 2.564 KM. (35D;46.53M)
LONGITUDE 93.7417 +/- 2.449 KM. (93D;44.50M)
DEPTH 0.00 +/- 0.000 KM.

STATION	PHASE	HR	MIN	SEC	+OR-SEC	DIST	AZ	OBS-THE	THEOR.
CBT	PLG	3	6	35.20	.10	66.73	247.0	.077	7595.12
CBT	SLG	3	6	43.60	.20	66.73	247.0	-.037	7603.64
TLT	PLG	3	6	36.00	.50	71.98	223.1	.027	7595.97
TLT	SLG	3	6	44.80	.20	71.98	223.1	-.293	7605.09
DCT	PLG	3	6	40.30	.50	100.77	217.7	-.449	7600.75
DCT	SLG	3	6	53.70	.30	100.77	217.7	.501	7613.20

ERROR ELLIPSE IS AS FOLLOWS:
SEMIMINOR AXIS LENGTH - 3.0429 KM.
SEMIMAJOR AXIS LENGTH - 3.4440 KM.
AZIMUTH OF MAJOR AXIS - 146.0901 DEG.
AREA OF ELLIPSE - 32.9223 SQ.KM.
ECCENTRICITY - .4684

MEAN RESIDUAL : -.02747 STANDARD DEVIATION : .32739

THE EVENT OCCURED ON DEC 1, 1982
AT ORIGIN TIME 13:39:44.95 +/- .126
TENN
MAGNITUDE: 2.4
THE WEIGHTS ARE
WX= 1.000 WY= 1.000 WZ= 0.000 WT= 1.000
IT WAS LOCATED AT
LATITUDE 35.2529 +/- .852 KM. (35D;15.17M)
LONGITUDE 84.4460 +/- .654 KM. (84D;26.76M)
DEPTH 0.00 +/- 0.000 KM.

STATION	PHASE	HR	MIN	SEC	+OR-SEC	DIST	AZ	OBS-THE	THEOR.
CBT	PLG	13	39	50.30	.10	31.85	4.1	-.320	49190.62
CBT	SLG	13	39	54.50	.10	31.85	4.1	-.603	49195.10
RCT	PLG	13	39	49.20	.10	22.18	297.6	.179	49189.02
RCT	SLG	13	39	52.30	.10	22.18	297.6	-.086	49192.39
TLT	PG	13	39	47.90	.10	15.68	70.1	.094	49187.81
TLT	S-P	0	0	2.20	.10	15.68	70.1	.113	2.09
RHT	PLG	13	39	52.80	.10	44.27	244.0	.127	49192.67
RHT	SLG	13	39	58.40	.10	44.27	244.0	-.191	49198.59
DCT	PG	13	39	49.00	.10	22.18	173.7	.013	49188.99
DCT	S	13	39	51.80	.10	22.18	173.7	-.139	49191.94
ETT	PG	13	39	47.30	.10	8.17	354.3	.859	49186.44

ERROR ELLIPSE IS AS FOLLOWS:
SEMIMINOR AXIS LENGTH = .7276 KM.
SEMIMAJOR AXIS LENGTH = .9553 KM.
AZIMUTH OF MAJOR AXIS = 173.0161 DEG.
AREA OF ELLIPSE = 2.1837 SQ.KM.
ECCENTRICITY = .6479

MEAN RESIDUAL : .00410 STANDARD DEVIATION : .36560

THE EVENT OCCURED ON DEC 6, 1982
AT ORIGIN TIME 10:52:35.46 +/- .406
STRAWBERRY PLAIN,TENN
MAGNITUDE: 2.2
THE WEIGHTS ARE
WX= 1.000 WY= 1.000 WZ= 0.000 WT= 1.000
IT WAS LOCATED AT
LATITUDE 36.1106 +/- 1.450 KM. (36D, 6.63M)
LONGITUDE 83.7539 +/- 1.688 KM. (83D,45.23M)
DEPTH 0.00 +/- 0.000 KM.

STATION	PHASE	HR	MIN	SEC	+OR-SEC	DIST	AZ	OBS-THE	THEOR.
TLT	PLG	10	52	52.20	.10	101.67	208.2	-.468	39172.67
TLT	SLG	10	53	5.00	.10	101.67	208.2	-.222	39185.22
DCT	PLG	10	52	57.30	.10	131.62	207.4	-.318	39177.62
DCT	SLG	10	53	13.50	.10	131.62	207.4	-.135	39193.63
CBT	PLG	10	52	50.00	.10	87.29	223.7	-.291	39170.29
CBT	SLG	10	53	1.50	.10	87.29	223.7	.318	39181.18
BHT	SLG	10	53	8.00	.10	111.17	254.8	.110	39187.89
TKL	PLG	10	52	44.80	.10	50.23	182.1	.635	39164.17
TKL	SLG	10	52	50.70	.10	50.23	182.1	-.072	39170.77
HPK	PLG	10	52	40.00	.10	23.37	208.9	.273	39159.73
HPK	SLG	10	52	43.40	.10	23.37	208.9	.171	39163.23

ERROR ELLIPSE IS AS FOLLOWS:
SEMIMINOR AXIS LENGTH = 1.4153 KM.
SEMIMAJOR AXIS LENGTH = 2.0458 KM.
AZIMUTH OF MAJOR AXIS = 57.6235 DEG.
AREA OF ELLIPSE = 9.0964 SQ.KM.
ECCENTRICITY = .7221

MEAN RESIDUAL : .00000 STANDARD DEVIATION : .33120

THE EVENT OCCURED ON DEC 8, 1982
AT ORIGIN TIME 23:36:56.31 +/- .459
MACON,GA
MAGNITUDE: 2.9
THE WEIGHTS ARE
WX= 1.000 WY= 1.000 WZ= 0.000 WT= 1.000
IT WAS LOCATED AT
LATITUDE 32.9820 +/- 1.852 KM. (32D,58.92M)
LONGITUDE 83.5075 +/- 2.178 KM. (83D,30.45M)
DEPTH 0.00 +/- 0.000 KM.

STATION	PHASE	HR	MIN	SEC	+OR-SEC	DIST	AZ	OBS-THE	THEOR.
BEV	SLG	23	37	37.30	.10	142.54	30.2	-.253	85057.55
LDV	S-P	0	0	19.30	.10	150.52	30.5	-.734	20.03
CRG	PN	23	37	29.20	.10	211.30	332.1	-.431	85049.63
DCT	SLG	23	38	6.90	.10	245.05	340.1	.550	85086.35
IVA	SLG	23	37	42.80	.10	159.80	26.1	.398	85062.40
TVG	PN	23	37	31.40	.10	228.14	313.1	-.273	85051.67
TVG	S-P	0	0	30.00	.10	228.14	313.1	-.365	30.37

ERROR ELLIPSE IS AS FOLLOWS:
SEMIMINOR AXIS LENGTH = 2.0727 KM.
SEMIMAJOR AXIS LENGTH = 3.1050 KM.
AZIMUTH OF MAJOR AXIS = 122.6144 DEG.
AREA OF ELLIPSE = 20.2183 SQ.KM.
ECCENTRICITY = .7446

MEAN RESIDUAL : -.15822 STANDARD DEVIATION : .46210

THE EVENT OCCURED ON DEC 11, 1982
AT ORIGIN TIME 0:25:10.38 +/- .851
MACON,GA,DEC,82
MAGNITUDE: 2
THE WEIGHTS ARE
WX= 1.000 WY= 1.000 WZ= 0.000 WT= 1.000
IT WAS LOCATED AT
LATITUDE 32.9425 +/- 2.632 KM. (32D,56.55M)
LONGITUDE 83.5093 +/- 5.132 KM. (83D,30.56M)

STATION	PHASE	HR	MIN	SEC	+OR-SEC	DIST	AZ	OBS-THE	THEOR.
IVA	PLG	0	25	38.00	.10	163.81	25.5	.140	1537.86
IVA	SLG	0	25	58.30	.10	163.81	25.5	.702	1557.60
LDV	PLG	0	25	35.60	.10	154.38	29.7	-.702	1536.30
LDV	SLG	0	25	55.30	.10	154.38	29.7	.351	1554.95
BEV	PLG	0	25	34.10	.10	146.41	29.4	-.884	1534.98
TVG	PLG	0	25	48.50	.10	231.13	314.0	-.488	1548.99
TVG	SLG	0	26	16.10	.10	231.13	314.0	-.409	1576.51
HGA	SLG	0	26	23.60	.10	262.90	304.2	-1.832	1585.43
DCT	PLG	0	25	51.60	.10	249.17	340.5	-.370	1551.97
DCT	SLG	0	26	22.50	.10	249.17	340.5	.924	1581.58
IVA	PN	0	25	37.10	.10	163.81	25.5	-.780	1537.88
LDV	PN	0	25	35.20	.10	154.38	29.7	-1.530	1536.73
TVG	PN	0	25	47.10	.10	231.13	314.0	.992	1546.11
HGA	PN	0	25	52.20	.10	262.90	304.2	2.211	1549.99
DCT	PN	0	25	50.00	.10	249.17	340.5	1.671	1548.33

ERROR ELLIPSE IS AS FOLLOWS:
SEMIMINOR AXIS LENGTH = 2.7728 KM.
SEMIMAJOR AXIS LENGTH = 5.5783 KM.
AZIMUTH OF MAJOR AXIS = 97.4408 DEG.
AREA OF ELLIPSE = 48.5929 SQ.KM.
ECCENTRICITY = .8677

THE EVENT OCCURED ON DEC 14, 1982
AT ORIGIN TIME 6:35: 9.58 +/- .124
TENN. N.C. BORDE
MAGNITUDE: 3.0
THE WEIGHTS ARE
WX= 1.000 WY= 1.000 WZ= 0.000 WT= 1.000
IT WAS LOCATED AT
LATITUDE 35.3021 +/- .748 KM. (35D,18.13M)
LONGITUDE 84.1300 +/- .765 KM. (84D, 7.80M)

STATION	PHASE	HR	MIN	SEC	+OR-SEC	DIST	AZ	OBS-THE	THEOR.
CRG	PLG	6	35	23.80	.20	82.34	210.2	.212	23723.59
CRG	SLG	6	35	33.20	.20	82.34	210.2	-.707	23733.91
DCT	PLG	6	35	16.50	.20	38.06	223.8	.231	23716.27
DCT	SLG	6	35	20.70	.20	38.06	223.8	-.769	23721.47
TLT	PLG	6	35	13.00	.20	13.95	269.5	.718	23712.28
TLT	SLG	6	35	15.00	.20	13.95	269.5	.305	23714.69
IVA	PLG	6	35	38.00	.20	169.98	131.9	-.073	23738.07
IVA	SLG	6	35	58.10	.20	169.98	131.9	-.425	23758.52
ETT	PLG	6	35	15.30	.20	29.68	275.1	.417	23714.88
ETT	SLG	6	35	18.70	.20	29.68	275.1	-.415	23719.11
TKL	PLG	6	35	18.70	.20	51.06	39.2	.283	23718.42
TKL	SLG	6	35	24.90	.20	51.06	39.2	-.220	23725.12
BBG	PLG	6	35	19.80	.20	55.64	148.4	.626	23719.17
BBG	SLG	6	35	26.80	.20	55.64	148.4	.393	23726.41
HPK	PLG	6	35	22.10	.20	72.88	18.1	.076	23722.02
HPK	SLG	6	35	30.60	.20	72.88	18.1	-.650	23731.25

ERROR ELLIPSE IS AS FOLLOWS:
SEMIMINOR AXIS LENGTH = .7520 KM.
SEMIMAJOR AXIS LENGTH = .8690 KM.
AZIMUTH OF MAJOR AXIS = 130.6364 DEG.
AREA OF ELLIPSE = 2.0530 SQ.KM.
ECCENTRICITY = .5012

MEAN RESIDUAL : .00005 STANDARD DEVIATION : .47837

THE EVENT OCCURED ON DEC 15, 1982
AT ORIGIN TIME 2:27:59.36 +/- .204
N. OF GREENBACK,TENN
MAGNITUDE: 2.6
THE WEIGHTS ARE
WX= 1.000 WY= 1.000 WZ= 0.000 WT= 1.000
IT WAS LOCATED AT
LATITUDE 35.7369 +/- 1.889 KM. (35D,44.22M)
LONGITUDE 84.2171 +/- 1.673 KM. (84D,13.02M)

STATION	PHASE	HR	MIN	SEC	+OR-SEC	DIST	AZ	OBS-THE	THEOR.
CBT	PLG	2	28	5.10	.10	28.62	220.1	.601	8884.50
CBT	SLG	2	28	9.40	.50	28.62	220.1	.792	8888.61
TLT	PLG	2	28	8.20	.20	48.66	187.1	.388	8887.81
TLT	SLG	2	28	14.40	.20	48.66	187.1	.161	8894.24
RHT	PLG	2	28	15.00	.10	94.68	219.7	-.418	8895.42
RHT	SLG	2	28	26.80	.20	94.68	219.7	-.364	8907.16
DCT	PLG	2	28	12.60	.20	77.87	193.7	-.040	8892.64
DCT	SLG	2	28	22.10	.20	77.87	193.7	-.343	8902.44
TVG	PLG	2	28	29.00	.20	179.95	213.5	-.513	8909.51
TVG	S-P	0	0	24.20	.20	179.95	213.5	.248	23.95
HPK	PLG	2	28	6.00	.20	37.06	55.5	.106	8885.89
HPK	SLG	2	28	10.90	.20	37.06	55.5	-.079	8890.98

ERROR ELLIPSE IS AS FOLLOWS:
SEMIMINOR AXIS LENGTH = .7978 KM.
SEMIMAJOR AXIS LENGTH = 2.6917 KM.
AZIMUTH OF MAJOR AXIS = 139.1319 DEG.
AREA OF ELLIPSE = 6.7463 SQ.KM.
ECCENTRICITY = .9551

MEAN RESIDUAL : .04502 STANDARD DEVIATION : .41656

THE EVENT OCCURED ON DEC 21, 1982
AT ORIGIN TIME 5:30:46.19 +/- .324
MACON,GA
MAGNITUDE: 2.7
THE WEIGHTS ARE
WX= 1.000 WY= 1.000 WZ= 0.000 WT= 1.000
IT WAS LOCATED AT
LATITUDE 32.7991 +/- .739 KM. (32D,47.95M)
LONGITUDE 83.5186 +/- 1.883 KM. (83D,31.12M)

STATION	PHASE	HR	MIN	SEC	+OR-SEC	DIST	AZ	OBS-THE	THEOR.
TVG	PLG	5	31	27.20	.10	241.92	316.8	.622	19886.58
TVG	SLG	5	31	56.00	.10	241.92	316.8	.653	19915.35
CRG	PLG	5	31	24.10	.10	229.02	334.7	-.347	19884.45
CRG	SLG	5	31	52.00	.10	229.02	334.7	.276	19911.72
CH6	PLG	5	31	12.20	.10	152.72	37.0	.365	19871.83
CH6	SLG	5	31	29.80	.10	152.72	37.0	-.491	19890.29
BEV	PLG	5	31	13.10	.10	160.86	26.9	-.080	19873.18
BEV	SLG	5	31	32.20	.10	160.86	26.9	-.377	19892.58
LDV	PLG	5	31	14.70	.10	168.79	27.2	.209	19874.49
IVA	PLG	5	31	16.40	.10	178.65	23.5	.280	19876.12
IVA	SLG	5	31	37.90	.10	178.65	23.5	.326	19897.57
TDA	PLG	5	31	27.80	.10	248.74	289.5	.095	19887.71
TDA	SLG	5	31	56.80	.10	248.74	289.5	-.462	19917.26
CH5	PLG	5	31	12.30	.10	153.32	47.2	.367	19871.93
CH5	SLG	5	31	30.00	.10	153.32	47.2	-.458	19890.46
HGA	PLG	5	31	31.00	.10	271.63	307.1	-.489	19891.49
HGA	SLG	5	32	3.20	.10	271.63	307.1	-.492	19923.69

ERROR ELLIPSE IS AS FOLLOWS:
SEMIMINOR AXIS LENGTH = .7241 KM.
SEMIMAJOR AXIS LENGTH = 2.0375 KM.
AZIMUTH OF MAJOR AXIS = 99.5664 DEG.
AREA OF ELLIPSE = 4.6346 SQ.KM.
ECCENTRICITY = .9347

MEAN RESIDUAL : -.00022 STANDARD DEVIATION : .41891

THE EVENT OCCURED ON JAN 5, 1983
AT ORIGIN TIME 23: 5:56.50 +/- .461
GOLD MINE,ALA
MAGNITUDE: 2.4
THE WEIGHTS ARE
WX= 1.000 WY= 1.000 WZ= 0.000 WT= 1.000
IT WAS LOCATED AT
LATITUDE 34.0175 +/- 2.359 KM. (34D, 1.05M)
LONGITUDE 87.6207 +/- 1.250 KM. (87D,37.24M)

STATION	PHASE	HR	MIN	SEC	+OR-SEC	DIST	AZ	OBS-THE	THEOR.
TVG	PLG	23	6	32.80	.10	217.77	79.4	-.107	83192.91
TVG	SLG	23	6	58.60	.10	217.77	79.4	-.284	83218.88
OCA	PLG	23	6	17.80	.10	127.88	58.7	-.250	83179.05
OCA	SLG	23	6	34.20	.10	127.88	58.7	.566	83193.63
TDA	PLG	23	6	22.80	.10	156.52	109.6	.017	83182.78
TDA	SLG	23	6	41.30	.10	156.52	109.6	-.378	83201.68
TSA	PLG	23	6	12.80	.10	98.66	148.6	-.419	83173.22
TSA	SLG	23	6	26.00	.10	98.66	148.6	.575	83185.42
HVA	PLG	23	6	10.20	.10	78.60	89.3	.296	83169.90

ERROR ELLIPSE IS AS FOLLOWS:
SEMIINOR AXIS LENGTH = 1.2781 KM.
SEMIMAJOR AXIS LENGTH = 2.8051 KM.
AZIMUTH OF MAJOR AXIS = 164.4306 DEG.
AREA OF ELLIPSE = 11.2632 SQ.KM.
ECCENTRICITY = .8902

MEAN RESIDUAL : .00166 STANDARD DEVIATION : .38920

THE EVENT OCCURED ON JAN 8, 1983
AT ORIGIN TIME 22:30:37.24 +/- .319
TRENTON,GA
MAGNITUDE: 2.3
THE WEIGHTS ARE
WX= 1.000 WY= 1.000 WZ= 0.000 WT= 1.000
IT WAS LOCATED AT
LATITUDE 34.9153 +/- 1.357 KM. (34D,54.92M)
LONGITUDE 85.5262 +/- 1.807 KM. (85D,31.57M)

STATION	PHASE	HR	MIN	SEC	+OR-SEC	DIST	AZ	OBS-THE	THEOR.
HGA	PLG	22	30	50.00	.10	78.33	202.1	-.590	81050.59
HGA	SLG	22	31	1.00	.10	78.33	202.1	.555	81060.45
OCA	PLG	22	30	52.50	.10	89.54	248.1	.056	81052.44
TDA	PLG	22	31	3.90	.10	159.00	196.9	-.024	81063.92
TVG	PLG	22	30	47.90	.10	63.10	161.0	-.173	81048.07
TVG	SLG	22	30	56.00	.10	63.10	161.0	-.168	81056.17
CRG	PLG	22	30	53.00	.10	90.84	108.2	.343	81052.66

ERROR ELLIPSE IS AS FOLLOWS:
SEMIMINOR AXIS LENGTH = 1.6573 KM.
SEMIMAJOR AXIS LENGTH = 2.2162 KM.
AZIMUTH OF MAJOR AXIS = 94.5857 DEG.
AREA OF ELLIPSE = 11.5387 SQ.KM.
ECCENTRICITY = .6639

MEAN RESIDUAL : .00000 STANDARD DEVIATION : .37301

THE EVENT OCCURED ON JAN 16, 1983
AT ORIGIN TIME 19:28:13.87 +/- .237
16,JAN,MACON,GA
MAGNITUDE: 2.6
THE WEIGHTS ARE
WX= 1.000 WY= 1.000 WZ= 0.000 WT= 1.000
IT WAS LOCATED AT
LATITUDE 32.7908 +/- .567 KM. (32D,47.45M)
LONGITUDE 83.5281 +/- 1.346 KM. (83D,31.69M)

STATION	PHASE	HR	MIN	SEC	+OR-SEC	DIST	AZ	OBS-THE	THEOR.
CRG	PLG	19	28	52.40	.10	229.49	335.0	.194	70132.21
CRG	SLG	19	29	19.50	.10	229.49	335.0	-.038	70159.54
TDA	PLG	19	28	55.30	.10	248.24	289.8	-.006	70135.31
TDA	SLG	19	29	24.70	.10	248.24	289.8	-.106	70164.81
BEV	PLG	19	28	41.00	.10	162.09	27.0	-.067	70121.07
BEV	SLG	19	29	.90	.10	162.09	27.0	.293	70140.61
LDV	PLG	19	28	42.00	.10	170.03	27.4	-.378	70122.38
LDV	SLG	19	29	3.00	.10	170.03	27.4	.165	70142.83
CH5	PLG	19	28	39.90	.10	154.60	47.2	.072	70119.83
CH5	SLG	19	28	58.20	.10	154.60	47.2	-.301	70138.50
TVG	PLG	19	28	54.80	.10	242.00	317.2	.525	70134.28
TVG	SLG	19	29	22.70	.10	242.00	317.2	-.353	70163.05

ERROR ELLIPSE IS AS FOLLOWS:
SEMIMINOR AXIS LENGTH = .5741 KM.
SEMIMAJOR AXIS LENGTH = 1.5094 KM.
AZIMUTH OF MAJOR AXIS = 100.3853 DEG.
AREA OF ELLIPSE = 2.7221 SQ.KM.
ECCENTRICITY = .9249

MEAN RESIDUAL : -.00001 STANDARD DEVIATION : .27086

THE EVENT OCCURED ON JAN 17, 1983
AT ORIGIN TIME 2: 6: 6.93 +/- .311
17,JAN,MACON,GA
MAGNITUDE: 2.8
THE WEIGHTS ARE
WX= 1.000 WY= 1.000 WZ= 0.000 WT= 1.000
IT WAS LOCATED AT
LATITUDE 32.7452 +/- .737 KM. (32D,44.71M)
LONGITUDE 83.5236 +/- 1.767 KM. (83D,31.42M)

STATION	PHASE	HR	MIN	SEC	+OR-SEC	DIST	AZ	OBS-THE	THEOR.
CRG	PLG	2	6	46.00	.10	234.27	335.4	-.048	7606.05
CRG	SLG	2	7	14.30	.10	234.27	335.4	.367	7633.93
TDA	PLG	2	6	49.00	.10	250.50	290.8	.270	7608.73
TDA	SLG	2	7	18.00	.10	250.50	290.8	-.490	7638.49
BEV	PLG	2	6	35.00	.10	166.44	26.1	.164	7594.84
BEV	SLG	2	6	55.00	.10	166.44	26.1	.122	7614.88
CH5	PLG	2	6	33.40	.10	157.80	45.7	-.009	7593.41
CH5	SLG	2	6	52.00	.10	157.80	45.7	-.452	7612.45
TVG	PLG	2	6	48.40	.10	246.06	317.9	.404	7608.00
TVG	SLG	2	7	16.90	.10	246.06	317.9	-.342	7637.24

ERROR ELLIPSE IS AS FOLLOWS:
SEMIMINOR AXIS LENGTH = .7857 KM.
SEMIMAJOR AXIS LENGTH = 2.0238 KM.
AZIMUTH OF MAJOR AXIS = 98.7551 DEG.
AREA OF ELLIPSE = 4.9954 SQ.KM.
ECCENTRICITY = .9216

THE EVENT OCCURED ON JAN 17, 1983
AT ORIGIN TIME 3:34:20.27 +/- .311
17,JAN,MACON,GA
MAGNITUDE: 2.6
THE WEIGHTS ARE
WX= 1.000 WY= 1.000 WZ= 0.000 WT= 1.000
IT WAS LOCATED AT
LATITUDE 32.7623 +/- .739 KM. (32D,45.74M)
LONGITUDE 83.5217 +/- 1.831 KM. (83D,31.30M)

STATION	PHASE	HR	MIN	SEC	+OR-SEC	DIST	AZ	OBS-THE	THEOR.
CRG	PLG	3	34	59.00	.10	232.62	335.2	-.117	12899.12
CRG	SLG	3	35	26.90	.10	232.62	335.2	.090	12926.81
TDA	PLG	3	35	1.90	.10	249.96	290.4	-.084	12901.98
TDA	SLG	3	35	31.60	.10	249.96	290.4	-.082	12931.68
BEV	PLG	3	34	48.20	.10	164.64	26.3	.318	12887.88
BEV	SLG	3	35	7.90	.10	164.64	26.3	.183	12907.72
CH6	PLG	3	34	45.90	.10	156.18	36.2	-.583	12886.48
CH5	SLG	3	35	4.90	.10	156.34	46.2	-.483	12905.38
TVG	PLG	3	35	1.20	.10	244.76	317.6	.076	12901.12
TVG	SLG	3	35	30.20	.10	244.76	317.6	-.021	12930.22
CH5	PLG	3	34	47.20	.10	156.34	46.2	.691	12886.51

ERROR ELLIPSE IS AS FOLLOWS:
SEMIMINOR AXIS LENGTH = .7916 KM.
SEMIMAJOR AXIS LENGTH = 2.0603 KM.
AZIMUTH OF MAJOR AXIS = 97.1775 DEG.
AREA OF ELLIPSE = 5.1236 SQ.KM.
ECCENTRICITY = .9233

MEAN RESIDUAL : -.00125 STANDARD DEVIATION : .35025

THE EVENT OCCURED ON JAN 18, 1983
AT ORIGIN TIME 5: 9:12.07 +/- .475
S.E. TENN.
MAGNITUDE: ?
THE WEIGHTS ARE
WX= 1.000 WY= 1.000 WZ= 0.000 WT= 1.000
IT WAS LOCATED AT
LATITUDE 35.5889 +/- 1.239 KM. (35D,35.33M)
LONGITUDE 84.2914 +/- 2.115 KM. (84D,17.49M)

STATION	PHASE	HR	MIN	SEC	+OR-SEC	DIST	AZ	OBS-THE	THEOR.
CRG	PLG	5	9	29.60	.10	106.40	194.5	-.466	18570.07
HGA	SLG	5	10	10.50	.50	203.81	224.2	-.030	18610.53
TLT	PLG	5	9	18.10	.10	31.89	178.7	.350	18557.75
TLT	SLG	5	9	22.00	.50	31.89	178.7	-.236	18562.24
DCT	PLG	5	9	22.50	.10	60.37	191.1	.042	18562.46
DCT	SLG	5	9	30.50	.50	60.37	191.1	.263	18570.24
OCA	SLG	5	10	15.80	.10	222.26	241.2	.088	18615.71

ERROR ELLIPSE IS AS FOLLOWS:
SEMIMINOR AXIS LENGTH = 1.3671 KM.
SEMIMAJOR AXIS LENGTH = 2.6726 KM.
AZIMUTH OF MAJOR AXIS = 73.3458 DEG.
AREA OF ELLIPSE = 11.4783 SQ.KM.
ECCENTRICITY = .8593

MEAN RESIDUAL : .00142 STANDARD DEVIATION : .28133

THE EVENT OCCURED ON JAN 18, 1983
AT ORIGIN TIME 11: 6:10.43 +/- .514
MACON?
MAGNITUDE:
THE WEIGHTS ARE
WX= 1.000 WY= 1.000 WZ= 0.000 WT= 1.000
IT WAS LOCATED AT
LATITUDE 32.8655 +/- 1.382 KM. (32D,51.93M)
LONGITUDE 83.5455 +/- 3.913 KM. (83D,32.73M)

STATION	PHASE	HR	MIN	SEC	+OR-SEC	DIST	AZ	OBS-THE	THEOR.
CRG	PLG	11	6	47.50	.20	221.28	334.5	.093	40007.41
CH5	PLG	11	6	35.50	.20	150.30	49.9	-.174	39995.67
CH5	SLG	11	6	54.20	.20	150.30	49.9	.350	40013.85
CH6	S-P	0	0	19.20	.20	148.50	39.5	-.565	19.76
TDA	PLG	11	6	50.50	.20	243.85	288.0	-.637	40011.14
TDA	SLG	11	7	20.50	.20	243.85	288.0	.371	40040.13

ERROR ELLIPSE IS AS FOLLOWS:
SEMIMINOR AXIS LENGTH = 1.3954 KM.
SEMIMAJOR AXIS LENGTH = 5.3207 KM.
AZIMUTH OF MAJOR AXIS = 103.3692 DEG.
AREA OF ELLIPSE = 23.3242 SQ.KM.
ECCENTRICITY = .9650

THE EVENT OCCURED ON JAN 20, 1983
AT ORIGIN TIME 8:15: 8.08 +/- .293
////// MACON, GA
MAGNITUDE: 2.9
THE WEIGHTS ARE
WX= 1.000 WY= 1.000 WZ= 0.000 WT= 1.000
IT WAS LOCATED AT
LATITUDE 32.8445 +/- .895 KM. (32D,50.67M)
LONGITUDE 83.5788 +/- 1.609 KM. (83D,34.73M)

STATION	PHASE	HR	MIN	SEC	+OR-SEC	DIST	AZ	OBS-THE	THEOR
RHT	PLG	8	15	54.00	.10	276.15	334.4	-.115	29754.12
RHT	SLG	8	16	26.60	.10	276.15	334.4	-.241	29786.84
TLT	PLG	8	15	55.20	.10	280.32	346.8	.395	29754.80
TLT	SLG	8	16	27.80	.10	280.32	346.8	-.213	29788.01
RCT	PLG	8	15	57.70	.10	295.29	340.5	.421	29757.28
RCT	SLG	8	16	31.70	.10	295.29	340.5	-.518	29792.22
DCT	PLG	8	15	51.30	.10	257.39	342.6	.285	29751.01
DCT	SLG	8	16	22.30	.10	257.39	342.6	.728	29781.57
TSA	PLG	8	16	2.40	.10	329.75	278.0	-.575	29762.98
CH5	SLG	8	15	52.10	.10	154.23	50.0	-.495	29752.59
TDA	PLG	8	15	49.10	.10	241.66	288.8	.685	29748.41
TDA	SLG	8	16	17.80	.10	241.66	288.8	.647	29777.15
HVA	PLG	8	16	1.80	.10	326.16	294.0	-.581	29762.38
HVA	SLG	8	16	40.20	.10	326.16	294.0	-.688	29800.89
CH6	PLG	8	15	34.00	.10	152.33	39.8	.352	29733.65
CH6	SLG	8	15	52.00	.10	152.33	39.8	-.059	29752.06
CH5	PLG	8	15	34.00	.10	154.23	50.0	.036	29733.96

ERROR ELLIPSE IS AS FOLLOWS:
SEMIMINOR AXIS LENGTH = .9080 KM.
SEMIMAJOR AXIS LENGTH = 1.7470 KM.
AZIMUTH OF MAJOR AXIS = 101.7023 DEG.
AREA OF ELLIPSE = 4.9834 SQ.KM.
ECCENTRICITY = .8543

THE EVENT OCCURED ON JAN 26, 1983
AT ORIGIN TIME 11:30:55.51 +/- .150
TELLICO PLAIN,TENN
MAGNITUDE: 2.1
THE WEIGHTS ARE
WX= 1.000 WY= 1.000 WZ= 0.000 WT= 1.000
IT WAS LOCATED AT
LATITUDE 35.4437 +/- 1.062 KM. (35D,26.62M)
LONGITUDE 84.1493 +/- 1.022 KM. (84D, 8.96M)

STATION	PHASE	HR	MIN	SEC	+OR-SEC	DIST	AZ	OBS-THE	THEOR
TLT	PG	11	30	59.70	.10	19.96	217.6	.559	41459.14
TLT	S	11	31	2.00	.20	19.96	217.6	.202	41461.80
DCT	PLG	11	31	3.80	.10	49.68	209.7	-.323	41464.12
DCT	SLG	11	31	10.50	.20	49.68	209.7	-.166	41470.67
CBT	PLG	11	31	.90	.10	26.82	293.3	.555	41460.35
CBT	SLG	11	31	4.00	.20	26.82	293.3	-.247	41464.25
ETT	PLG	11	31	1.00	.10	30.67	244.8	.018	41460.98
ETT	SLG	11	31	4.30	.20	30.67	244.8	-1.028	41465.33
TKL	SLG	11	31	8.20	.20	41.54	55.0	-.179	41468.38
HPK	SLG	11	31	13.00	.20	58.86	24.5	-.246	41473.25
TKL	PLG	11	31	2.80	.10	41.54	55.0	.023	41462.78

ERROR ELLIPSE IS AS FOLLOWS:
SEMIMINOR AXIS LENGTH = .7453 KM.
SEMIMAJOR AXIS LENGTH = 1.4999 KM.
AZIMUTH OF MAJOR AXIS = 136.8126 DEG.
AREA OF ELLIPSE = 3.5120 SQ.KM.
ECCENTRICITY = .8678

MEAN RESIDUAL : -.07566 STANDARD DEVIATION : .44060

THE EVENT OCCURED ON JAN 26, 1983
AT ORIGIN TIME 12:32: 7.58 +/- .438
///// MACON, GA
MAGNITUDE: ////
THE WEIGHTS ARE
WX= 1.000 WY= 1.000 WZ= 0.000 WT= 1.000
IT WAS LOCATED AT
LATITUDE 32.8495 +/- 1.058 KM. (32D,50.97M)
LONGITUDE 83.5348 +/- 2.561 KM. (83D,32.09M)

STATION	PHASE	HR	MIN	SEC	+OR-SEC	DIST	AZ	OBS-THE	THEOR.
HGA	~~SLGS~~	12	33	24.30	.10	267.02	306.3	.515	45203.79
CH5	PLG	12	32	33.00	.10	150.70	49.2	.112	45152.89
CH5	SLG	12	32	51.00	.10	150.70	49.2	-.110	45171.11
TVG	~~SLGS~~	12	33	15.40	.10	236.80	316.2	.103	45195.30
TLT	~~SLGS~~	12	33	27.20	.10	280.77	345.9	-.448	45207.65
TDA	~~PLGP~~	12	32	48.10	.10	245.40	288.4	-.441	45168.54
TDA	~~SLGS~~	12	33	17.20	.10	245.40	288.4	-.511	45197.71
TVG	~~PLGP~~	12	32	47.90	.10	236.80	316.2	.780	45167.12

ERROR ELLIPSE IS AS FOLLOWS:
SEMIMINOR AXIS LENGTH = 1.2306 KM.
SEMIMAJOR AXIS LENGTH = 3.0383 KM.
AZIMUTH OF MAJOR AXIS = 94.7240 DEG.
AREA OF ELLIPSE = 11.7464 SQ.KM.
ECCENTRICITY = .9143

MEAN RESIDUAL : -.00000 STANDARD DEVIATION : .47281

THE EVENT OCCURED ON JAN 26, 1983
AT ORIGIN TIME 14: 7:44.71 +/- .234
MACON,GA
MAGNITUDE: 3.5
THE WEIGHTS ARE
WX= 1.000 WY= 1.000 WZ= 0.000 WT= 1.000
IT WAS LOCATED AT
LATITUDE 32.8528 +/- .640 KM. (32D,51.17M)
LONGITUDE 83.5882 +/- 1.313 KM. (83D,35.29M)

STATION	PHASE	HR	MIN	SEC	+OR-SEC	DIST	AZ	OBS-THE	THEOR.
TSA	PLG	14	8	39.00	.10	328.74	277.9	-.450	50919.45
DCT	PLG	14	8	27.50	.10	256.24	342.7	.034	50907.47
DCT	SLG	14	8	58.00	.10	256.24	342.7	.110	50937.89
TLT	PLG	14	8	31.50	.10	279.21	346.9	.237	50911.26
TLT	SLG	14	9	4.00	.10	279.21	346.9	-.343	50944.34
RHT	PLG	14	8	30.60	.10	274.93	334.4	.045	50910.56
RHT	SLG	14	9	2.70	.10	274.93	334.4	-.439	50943.14
HGA	PLG	14	8	28.90	.10	262.76	306.9	.356	50908.54
HGA	SLG	14	9	.50	.10	262.76	306.9	.778	50939.72
HVA	PLG	14	8	38.80	.10	324.97	293.9	-.026	50918.83
HVA	SLG	14	9	16.80	.10	324.97	293.9	-.395	50957.20
CH5	PLG	14	8	10.20	.10	154.30	50.5	-.416	50890.62
CH5	SLG	14	8	29.50	.10	154.30	50.5	.246	50909.25
LDV	PLG	14	8	13.00	.10	166.74	30.2	.327	50892.67
LDV	SLG	14	8	32.90	.10	166.74	30.2	.151	50912.75
CH6	PLG	14	8	10.50	.10	152.17	40.3	.236	50890.26
CH6	SLG	14	8	28.20	.10	152.17	40.3	-.456	50908.66

ERROR ELLIPSE IS AS FOLLOWS:
SEMIMINOR AXIS LENGTH = .6560 KM.
SEMIMAJOR AXIS LENGTH = 1.4171 KM.
AZIMUTH OF MAJOR AXIS = 98.8970 DEG.
AREA OF ELLIPSE = 2.9203 SQ.KM.
ECCENTRICITY = .8864

MEAN RESIDUAL : -.00039 STANDARD DEVIATION : .36236

THE EVENT OCCURED ON JAN 26, 1983
AT ORIGIN TIME 14:17:39.83 +/- .343
//// MACON, GA
MAGNITUDE: ////
THE WEIGHTS ARE
WX= 1.000 WY= 1.000 WZ= 0.000 WT= 1.000
IT WAS LOCATED AT
LATITUDE 32.8230 +/- .783 KM. (32D,49.38M)
LONGITUDE 83.5517 +/- 2.015 KM. (83D,33.10M)

STATION	PHASE	HR	MIN	SEC	+OR-SEC	DIST	AZ	OBS-THE	THEOR.
HGA	SLG	14	18	55.70	.10	267.53	307.0	-.481	51536.18
CH6	PLG	14	18	5.50	.10	152.54	38.5	.056	51485.44
CH6	SLG	14	18	23.70	.10	152.54	38.5	-.180	51503.88
LDV	PLG	14	18	7.90	.10	167.92	28.6	-.087	51487.99
LDV	SLG	14	18	27.80	.10	167.92	28.6	-.401	51508.20
CH5	PLG	14	18	6.00	.10	153.84	48.7	.341	51485.66
CH5	SLG	14	18	24.40	.10	153.84	48.7	.155	51504.25
DCT	PLG	14	18	22.80	.10	260.44	342.3	-.479	51503.28
DCT	SLG	14	18	55.00	.10	260.44	342.3	.811	51534.19
TDA	PLG	14	18	20.90	.10	244.90	289.1	.190	51500.71
TDA	SLG	14	18	49.90	.10	244.90	289.1	.077	51529.82

ERROR ELLIPSE IS AS FOLLOWS:
SEMIMINOR AXIS LENGTH = .8054 KM.
SEMIMAJOR AXIS LENGTH = 2.2788 KM.
AZIMUTH OF MAJOR AXIS = 99.2327 DEG.
AREA OF ELLIPSE = 5.7660 SQ.KM.
ECCENTRICITY = .9355

MEAN RESIDUAL : .00003 STANDARD DEVIATION : .38781

THE EVENT OCCURED ON JAN 27, 1983
AT ORIGIN TIME 22: 9:33.31 +/- .319
N. OF STRAWBERRY PLAINS, TENN
MAGNITUDE: 3.2
THE WEIGHTS ARE
WX= 1.000 WY= 1.000 WZ= 0.000 WT= 1.000
IT WAS LOCATED AT
LATITUDE 36.2187 +/- 2.447 KM. (36D,13.12M)
LONGITUDE 84.0082 +/- 1.601 KM. (84D, .49M)

STATION	PHASE	HR	MIN	SEC	+OR-SEC	DIST	AZ	OBS-THE	THEOR
DCT	PLG	22	9	56.00	.10	134.37	196.2	.084	79795.92
DCT	SLG	22	10	11.70	.20	134.37	196.2	-.551	79812.25
TLT	PLG	22	9	51.40	.10	104.76	193.8	.379	79791.02
TLT	SLG	22	10	3.80	.20	104.76	193.8	-.133	79803.93
CBT	S-P	0	0	11.20	.20	83.99	206.4	.021	11.18
TDA	PLG	22	10	30.80	.10	347.90	212.2	-.410	79831.21
TDA	SLG	22	11	12.00	.20	347.90	212.2	-.231	79872.23
TVG	PLG	22	10	12.70	.10	235.09	210.2	.136	79812.56
TVG	SLG	22	10	40.90	.20	235.09	210.2	.356	79840.54
HGA	PLG	22	10	18.90	.10	272.97	217.9	.076	79818.82
HGA	SLG	22	10	51.70	.20	272.97	217.9	.518	79851.18
HVA	PLG	22	10	30.90	.10	347.50	226.4	-.244	79831.14

ERROR ELLIPSE IS AS FOLLOWS:
SEMIMINOR AXIS LENGTH = 1.5478 KM.
SEMIMAJOR AXIS LENGTH = 2.8390 KM.
AZIMUTH OF MAJOR AXIS = 158.8285 DEG.
AREA OF ELLIPSE = 13.8048 SQ.KM.
ECCENTRICITY = .8383

MEAN RESIDUAL : .00006 STANDARD DEVIATION : .32644

THE EVENT OCCURED ON JAN 29, 1983
AT ORIGIN TIME 4:55:37.81 +/- .429
MACON
MAGNITUDE: ~~3.9~~ 3.0
THE WEIGHTS ARE
WX= 1.000 WY= 1.000 WZ= 0.000 WT= 1.000
IT WAS LOCATED AT
LATITUDE 32.8917 +/- 1.150 KM. (32D,53.50M)
LONGITUDE 83.5518 +/- 2.485 KM. (83D,33.11M)

STATION	PHASE	HR	MIN	SEC	+OR-SEC	DIST	AZ	OBS-THE	THEOR
TVG	PLG	4	56	17.50	.10	232.30	315.7	.895	17776.61
DCT	SLG	4	56	50.90	.10	253.20	341.7	.768	17810.13
HGA	PLG	4	56	22.00	.10	262.92	305.7	.333	17781.67
HGA	SLG	4	56	54.00	.10	262.92	305.7	1.136	17812.86
HVA	PLG	4	56	32.30	.10	326.28	293.0	.160	17792.14
HVA	SLG	4	57	9.20	.10	326.28	293.0	-1.462	17830.66
TDA	PLG	4	56	18.00	.10	242.34	287.4	-.266	17778.27
TDA	SLG	4	56	47.50	.10	242.34	287.4	.416	17807.08
DCT	PLG	4	56	20.20	.10	253.20	341.7	.140	17780.06
TLT	SLG	4	56	56.20	.10	275.84	346.0	-.293	17816.49
CH5	PLG	4	56	3.00	.10	148.90	50.9	.179	17762.82
CH5	SLG	4	56	20.70	.10	148.90	50.9	-.135	17780.83
CH6	PLG	4	56	2.80	.10	146.66	40.4	.350	17762.45
CH6	SLG	4	56	20.20	.10	146.66	40.4	-.004	17780.20
CBT	PLG	4	56	28.50	.10	304.69	345.0	-.072	17788.57
TLT	PLG	4	56	22.80	.10	275.84	346.0	-1.003	17783.80
RHT	PLG	4	56	22.50	.10	272.58	333.4	-.764	17783.26
RHT	SLG	4	56	55.20	.10	272.58	333.4	-.377	17815.58

ERROR ELLIPSE IS AS FOLLOWS:
SEMIMINOR AXIS LENGTH = 1.1690 KM.
SEMIMAJOR AXIS LENGTH = 2.6699 KM.
AZIMUTH OF MAJOR AXIS = 98.6904 DEG.

THE EVENT OCCURED ON JAN 29, 1983.
AT ORIGIN TIME 5: 4:21.47 +/- .282
MACON
MAGNITUDE: ≡ 2.5
THE WEIGHTS ARE
WX= 1.000 WY= 1.000 WZ= 0.000 WT= 1.000
IT WAS LOCATED AT
LATITUDE 32.8005 +/- .657 KM. (32D,48.03M)
LONGITUDE 83.5122 +/- 1.665 KM. (83D,30.73M)

STATION	PHASE	HR	MIN	SEC	+OR-SEC	DIST	AZ	OBS-THE	THEOR.
CH5	PLG	5	4	47.40	.10	152.77	47.1	.277	18287.12
CH5	SLG	5	5	5.00	.10	152.77	47.1	-.585	18305.58
CH6	PLG	5	4	47.50	.10	152.24	36.9	.464	18287.04
CH6	SLG	5	5	5.50	.10	152.24	36.9	.064	18305.44
DCT	PLG	5	5	5.20	.10	263.99	341.7	-.306	18305.51
DCT	SLG	5	5	36.90	.10	263.99	341.7	.074	18336.83
TDA	PLG	5	5	2.90	.10	249.27	289.4	-.173	18303.07
TDA	SLG	5	5	32.50	.10	249.27	289.4	-.190	18332.69
TVG	PLG	5	5	2.10	.10	242.24	316.7	.189	18301.91
TVG	SLG	5	5	30.90	.10	242.24	316.7	.183	18330.72

ERROR ELLIPSE IS AS FOLLOWS:
SEMIMINOR AXIS LENGTH = .7073 KM.
SEMIMAJOR AXIS LENGTH = 1.9027 KM.
AZIMUTH OF MAJOR AXIS = 97.6278 DEG.
AREA OF ELLIPSE = 4.2279 SQ.KM.
ECCENTRICITY = .9283

MEAN RESIDUAL : -.00027 STANDARD DEVIATION : .31137

THE EVENT OCCURED ON JAN 29, 1983
AT ORIGIN TIME 18: 8:30.25 +/- .554
STRAWBERRY PLAIN,TENN
MAGNITUDE: 2.7
THE WEIGHTS ARE
WX= 1.000 WY= 1.000 WZ= 0.000 WT= 1.000
IT WAS LOCATED AT
LATITUDE 36.1021 +/- 2.339 KM. (36D, 6.13M)
LONGITUDE 83.7968 +/- 2.505 KM. (83D,47.81M)

STATION	PHASE	HR	MIN	SEC	+OR-SEC	DIST	AZ	OBS-THE	THEOR.
ETT	PLG	18	8	48.50	.10	104.52	214.8	.574	65327.93
ETT	SLG	18	9	1.10	.10	104.52	214.8	.291	65340.81
TKL	PLG	18	8	39.10	.10	49.30	177.6	.302	65318.80
TKL	SLG	18	8	46.00	.10	49.30	177.6	.703	65325.30
BBG	PLG	18	8	52.60	.10	136.24	180.5	-.568	65333.17
BBG	SLG	18	9	9.30	.10	136.24	180.5	-.419	65349.72
TLT	PLG	18	8	46.80	.10	99.07	206.5	-.224	65327.02
TLT	SLG	18	8	59.20	.10	99.07	206.5	-.078	65339.28
DCT	PLG	18	8	51.80	.10	129.06	206.0	-.181	65331.98
DCT	SLG	18	9	7.30	.10	129.06	206.0	-.401	65347.70

ERROR ELLIPSE IS AS FOLLOWS:
SEMIMINOR AXIS LENGTH = 2.6522 KM.
SEMIMAJOR AXIS LENGTH = 2.8399 KM.
AZIMUTH OF MAJOR AXIS = 90.8026 DEG.
AREA OF ELLIPSE = 23.6627 SQ.KM.
ECCENTRICITY = .3575

MEAN RESIDUAL : -.00000 STANDARD DEVIATION : .44061

THE EVENT OCCURED ON JAN 31, 1983
AT ORIGIN TIME 23:41: 1.07 +/- .178
HONEA PATH, S.C.
MAGNITUDE: 2.7
THE WEIGHTS ARE
WX= 1.000 WY= 1.000 WZ= 0.000 WT= 1.000
IT WAS LOCATED AT
LATITUDE 34.3006 +/- .889 KM. (34D,18.04M)
LONGITUDE 82.4199 +/- .826 KM. (82D,25.20M)

STATION	PHASE	HR	MIN	SEC	+OR-SEC	DIST	AZ	OBS-THE	THEOR
ETT	PLG	23	41	37.30	.10	219.12	301.6	-.399	85297.70
ETT	SLG	23	42	3.80	.10	219.12	301.6	-.032	85323.83
TKL	PLG	23	41	34.10	.10	195.44	320.8	.316	85293.78
TKL	SLG	23	41	56.20	.10	195.44	320.8	-.979	85317.18
BBG	PLG	23	41	25.60	.10	142.94	296.6	.493	85285.11
BBG	SLG	23	41	42.70	.10	142.94	296.6	.268	85302.43
BEN	PLG	23	41	27.35	.10	156.75	26.1	-.040	85287.39
BEN	SLG	23	41	46.40	.10	156.75	26.1	.087	85306.31
CBT	PLG	23	41	38.90	.10	229.74	307.1	-.554	85299.45
DCT	SLG	23	41	59.00	.10	202.11	294.6	-.054	85319.05
TLT	PLG	23	41	35.50	.10	204.26	303.2	.258	85295.24
TLT	SLG	23	42	0.00	.10	204.26	303.2	.343	85319.66
DCT	PLG	23	41	35.50	.10	202.11	294.6	.612	85294.89
LDV	PLG	23	41	6.20	.10	29.58	235.1	-.170	85266.37
LDV	SLG	23	41	10.30	.10	29.58	235.1	-.289	85270.59
IVA	PLG	23	41	6.70	.10	30.16	264.0	.234	85266.47
IVA	SLG	23	41	10.80	.10	30.16	264.0	.047	85270.75
CH6	PLG	23	41	9.00	.10	46.26	192.6	-.127	85269.13

ERROR ELLIPSE IS AS FOLLOWS:
SEMIMINOR AXIS LENGTH = .8047 KM.
SEMIMAJOR AXIS LENGTH = 1.0101 KM.
AZIMUTH OF MAJOR AXIS = 144.6410 DEG.
AREA OF ELLIPSE = 2.5538 SQ.KM.
ECCENTRICITY = .6045

THE EVENT OCCURED ON JAN 31, 1983
AT ORIGIN TIME 23: 4: 8.55 +/- .772
~~BA~~
MAGNITUDE: ~~3.5~~ 2.1
THE WEIGHTS ARE
WX= 1.000 WY= 1.000 WZ= 0.000 WT= 1.000
IT WAS LOCATED AT
LATITUDE 34.9624 +/- 2.908 KM. (34D,57.74M)
LONGITUDE 85.5117 +/- 3.535 KM. (85D,30.70M)

STATION	PHASE	HR	MIN	SEC	+OR-SEC	DIST	AZ	OBS-THE	THEOR
HGA	PLG	23	4	22.50	.10	83.66	201.6	-.284	83062.78
HGA	SLG	23	4	32.70	.10	83.66	201.6	-.556	83073.26
TDA	PLG	23	4	36.20	.10	164.38	196.8	.075	83076.13
TDA	SLG	23	4	56.70	.10	164.38	196.8	.771	83095.93
TVG	PLG	23	4	20.40	.10	67.67	163.5	.259	83060.14
TVG	SLG	23	4	28.50	.10	67.67	163.5	-.264	83068.76

ERROR ELLIPSE IS AS FOLLOWS:
SEMIMINOR AXIS LENGTH = 3.7245 KM.
SEMIMAJOR AXIS LENGTH = 4.5878 KM.
AZIMUTH OF MAJOR AXIS = 100.0685 DEG.
AREA OF ELLIPSE = 53.6811 SQ.KM.
ECCENTRICITY = .5839

THE EVENT OCCURED ON FEB 5, 1983
AT ORIGIN TIME 13: 8:18.24 +/- .446
ALA-TENN
MAGNITUDE: 3
THE WEIGHTS ARE
WX= 1.000 WY= 1.000 WZ= 0.000 WT= 1.000
IT WAS LOCATED AT
LATITUDE 34.6952 +/- 2.207 KM. (34D,41.71M)
LONGITUDE 88.3318 +/- 1.741 KM. (88D,19.91M)

STATION	PHASE	HR	MIN	SEC	+OR-SEC	DIST	AZ	OBS-THE	THEOR.
TDA	PLG	13	8	58.90	.10	247.04	120.8	-.575	47339.47
DCT	PLG	13	9	18.00	.10	360.59	83.6	-.243	47358.24
TSA	PLG	13	8	51.30	.10	197.21	143.6	.061	47331.24
TSA	SLG	13	9	14.90	.10	197.21	143.6	.062	47354.84
HGA	PLG	13	8	57.50	.10	232.71	101.9	.394	47337.11
HGA	SLG	13	9	25.00	.10	232.71	101.9	.191	47364.81
HVA	PLG	13	8	45.70	.10	161.20	117.2	.413	47325.29
HVA	SLG	13	9	4.50	.10	161.20	117.2	-.223	47344.72

ERROR ELLIPSE IS AS FOLLOWS:
SEMIMINOR AXIS LENGTH = 2.0419 KM.
SEMIMAJOR AXIS LENGTH = 2.6285 KM.
AZIMUTH OF MAJOR AXIS = 170.1183 DEG.
AREA OF ELLIPSE = 16.8613 SQ.KM.
ECCENTRICITY = .6297

MEAN RESIDUAL : .01012 STANDARD DEVIATION : .33989

THE EVENT OCCURED ON FEB 10, 1983
AT ORIGIN TIME 6:18:59.60 +/- .287
TENN-VIR BORDER
MAGNITUDE: 2.8
THE WEIGHTS ARE
WX= 1.000 WY= 1.000 WZ= 0.000 WT= 1.000
IT WAS LOCATED AT
LATITUDE 36.8351 +/- 1.653 KM. (36D,50.11M)
LONGITUDE 82.8819 +/- 1.663 KM. (82D,52.92M)

STATION	PHASE	HR	MIN	SEC	+OR-SEC	DIST	AZ	OBS-THE	THEOR
TKL	PLG	6	19	25.50	.10	152.93	211.7	.220	22765.28
TKL	SLG	6	19	44.30	.10	152.93	211.7	.540	22783.76
BBG	PLG	6	19	38.20	.10	232.81	201.3	-.283	22778.48
CBT	SLG	6	19	56.50	.10	198.75	224.1	-.132	22796.63
ETT	PLG	6	19	35.80	.10	218.45	220.5	-.310	22776.11
ETT	SLG	6	20	2.20	.10	218.45	220.5	.035	22802.16
BHT	PLG	6	19	35.40	.10	214.21	239.5	-.009	22775.41
BHT	SLG	6	20	1.00	.10	214.21	239.5	.027	22800.97
TLT	PLG	6	19	35.20	.10	211.16	216.8	.295	22774.90
TLT	SLG	6	20	0.00	.10	211.16	216.8	-.117	22800.12
DCT	PLG	6	19	39.60	.10	240.50	215.4	-.155	22779.76
DCT	SLG	6	20	8.00	.10	240.50	215.4	-.360	22808.36
CBT	PLG	6	19	33.10	.10	198.75	224.1	.246	22772.85

ERROR ELLIPSE IS AS FOLLOWS:
SEMIMINOR AXIS LENGTH = 1.4008 KM.
SEMIMAJOR AXIS LENGTH = 2.1527 KM.
AZIMUTH OF MAJOR AXIS = 134.5543 DEG.
AREA OF ELLIPSE = 9.4736 SQ.KM.
ECCENTRICITY = .7593

MEAN RESIDUAL : -.00020 STANDARD DEVIATION : .26629

THE EVENT OCCURED ON FEB 11, 1983
AT ORIGIN TIME 1:15:37.79 +/- .253
BLUE SPRINGS,TENN
MAGNITUDE: 2.2
THE WEIGHTS ARE
WX= 1.000 WY= 1.000 WZ= 0.000 WT= 1.000
IT WAS LOCATED AT
LATITUDE 35.0648 +/- 1.123 KM. (35D, 3.89M)
LONGITUDE 84.9879 +/- .909 KM. (84D,59.27M)

STATION	PHASE	HR	MIN	SEC	+OR-SEC	DIST	AZ	OBS-THE	THEOR
TLT	PLG	1	15	49.80	.10	69.40	67.8	.135	4549.66
TLT	SLG	1	15	59.30	.10	69.40	67.8	-.199	4559.49
DCT	PLG	1	15	46.80	.10	51.86	91.3	.035	4546.77
DCT	SLG	1	15	53.60	.10	51.86	91.3	.039	4553.56
CBT	PLG	1	15	50.20	.10	73.81	44.3	-.193	4550.39
CBT	SLG	1	15	59.90	.10	73.81	44.3	.173	4559.73

ERROR ELLIPSE IS AS FOLLOWS:
SEMIMINOR AXIS LENGTH - 1.1100 KM.
SEMIMAJOR AXIS LENGTH - 1.4984 KM.
AZIMUTH OF MAJOR AXIS - 22.0230 DEG.
AREA OF ELLIPSE - 5.2251 SQ.KM.
ECCENTRICITY - .6717

MEAN RESIDUAL : -.00001 STANDARD DEVIATION : .15739

THE EVENT OCCURED ON FEB 23, 1983
AT ORIGIN TIME 8:51:32.23 +/- .599
TENN-MISS BORDER
MAGNITUDE: 3.4
THE WEIGHTS ARE
WX= 1.000 WY= 1.000 WZ= 0.000 WT= 1.000
IT WAS LOCATED AT
LATITUDE 35.4037 +/- 3.023 KM. (35D,24.22M)
LONGITUDE 89.1999 +/- 2.629 KM. (89D,11.99M)

STATION	PHASE	HR	MIN	SEC	+OR-SEC	DIST	AZ	OBS-THE	THEOR
DCT	SLG	8	53	36.00	.20	435.95	95.1	.113	32015.89
TDA	SLG	8	53	12.80	.20	354.72	125.0	-.268	31993.07
TSA	PLG	8	52	23.00	.10	307.00	140.2	-.372	31943.37
DCT	PLG	8	52	44.90	.10	435.95	95.1	.213	31964.69
TLT	PLG	8	52	46.00	.20	446.73	91.5	-.469	31966.47
CBT	PLG	8	52	44.00	.20	434.38	88.0	-.427	31964.43
HVA	PLG	8	52	17.70	.10	268.48	124.2	.695	31937.01

ERROR ELLIPSE IS AS FOLLOWS:
SEMIMINOR AXIS LENGTH = 3.1990 KM.
SEMIMAJOR AXIS LENGTH = 3.8278 KM.
AZIMUTH OF MAJOR AXIS = 160.6905 DEG.
AREA OF ELLIPSE = 38.4693 SQ.KM.
ECCENTRICITY = .5491

MEAN RESIDUAL : -.07344 STANDARD DEVIATION : .43121

THE EVENT OCCURED ON FEB 27, 1983
AT ORIGIN TIME 23:52:17.28 +/- .290
MADISONVILLE,TENN
MAGNITUDE: 2.1
THE WEIGHTS ARE
WX= 1.000 WY= 1.000 WZ= 0.000 WT= 1.000
IT WAS LOCATED AT
LATITUDE 35.4544 +/- 1.558 KM. (35D,27.27M)
LONGITUDE 84.5794 +/- .768 KM. (84D,34.76M)

STATION	PHASE	HR	MIN	SEC	+OR-SEC	DIST	AZ	OBS-THE	THEOR
DCT	PLG	23	52	25.30	.50	46.70	161.8	-.106	85945.41
DCT	SLG	23	52	31.30	.20	46.70	161.8	-.305	85951.61
CBT	PG	23	52	20.60	.10	17.22	56.8	.183	85940.42
CBT	S	23	52	22.50	.10	17.22	56.8	-.209	85942.71
TLT	PLG	23	52	23.00	.10	31.79	122.3	.058	85942.94
TLT	SLG	23	52	27.70	.20	31.79	122.3	.282	85947.42

ERROR ELLIPSE IS AS FOLLOWS:
SEMIMINOR AXIS LENGTH = .7541 KM.
SEMIMAJOR AXIS LENGTH = 2.1190 KM.
AZIMUTH OF MAJOR AXIS = 160.9216 DEG.
AREA OF ELLIPSE = 5.0203 SQ.KM.
ECCENTRICITY = .9345

MEAN RESIDUAL : -.01602 STANDARD DEVIATION : .22935

GEORGIA INSTITUTE OF TECHNOLOGY

QUARTERLY EARTHQUAKE BULLETIN

1 March 1983 - 31 May 1983

By

Leland Timothy Long, Anton M. Dainty, Jeffrey K. Wilson,

Anthony P. Johnson, Jeih-San Liow, Robert M. Duckworth, and An Tie

School of Geophysical Sciences

Earth Sciences Division

Supported by:

Alabama Geological Survey
(through contract with U.S. Nuclear Regulatory Commission)

Georgia Power Company

U.S. Army Corps of Engineers
(Savannah District)

U.S. Geological Survey
(Contract No. 14-08-0001-21241)

Tennessee Valley Authority

U.S. Army Corps of Engineers
(Mobile District)

QUARTERLY EARTHQUAKE BULLETIN

1 March 1983 - 31 May 1983

The information presented in this bulletin includes the origin times, magnitudes, hypocentral coordinates and their precision, and the arrival times of selected phases for local earthquakes recorded by seismic stations maintained by Georgia Tech, School of Geophysical Sciences.

The network consists of 23 seismic stations located in Alabama, southeast Tennessee, Georgia, and South Carolina monitored by the School of Geophysical Sciences at Georgia Tech. Additional seismogram readings were obtained from stations operated by the Tennessee Valley Authority and the Tennessee Earthquake Information Center. The coordinates of the stations used in locating the events are given in Table 1. A map of the seismic stations maintained by Georgia Tech is given in Figure 1. Bollinger and Mathena (1983) describe the instrumentation of the seismic network and magnitude threshold.

The events are located using a computer program with techniques similar to those used in HYP071 but is more flexible in assigning weights and utilizing phases.

Magnitudes are defined by their duration according to the equation:

$$m_b(Lg)_{Dur} = -1.7 + 2.21 \log_{10} T ,$$

where T is the mean signal duration in seconds (Chaplin, Taylor, and Toksöz, 1980). A map showing the epicenters can be seen in Figure 2 and is followed by data sheets containing information and individual events that occurred during the quarter.

References

Bollinger, G. A., and E. Mathena (1983). Seismicity of the southeastern United States, Southeastern U.S. Network Bulletin, 11, May 1983.

Chaplin, M. P., S. R. Taylor, and M. N. Toksöz (1980). A coda-length magnitude scale for New England, Earthquake Notes, 51, No. 4, 15-22.

Table 1. Coordinates of stations used in locating the events in this report.

Station	Latitude	Longitude	Elevation (km)
BBG	34.8740	83.8110	.1355
BEV	34.0893	82.7334	.1584
BHT	35.8470	84.9450	.8260
BKA	33.6339	87.9690	.1219
CBT	35.5394	84.4206	.3566
CDG	34.6108	84.6667	.3322
CH5	33.7332	82.3118	.1143
DCT	35.0542	84.4194	.5075
EBZ	35.1410	89.3510	.1690
ETT	35.3260	84.4550	.5880
HPK	35.9260	83.8790	.3048
HVA	34.0264	86.7692	.1951
MLA	32.7055	87.6936	.0549
OCA	34.6138	86.4352	.2499
PWL	34.9800	88.064	.2040
RCT	35.3453	84.6614	.2652
RHT	35.0781	84.8825	.2987
TDA	33.5417	86.0247	.1814
TLT	35.3011	84.2833	.5121
TKL	35.6581	83.7742	.3500
TSA	33.2561	87.0675	.1798
TVG	34.3771	85.3023	.3231

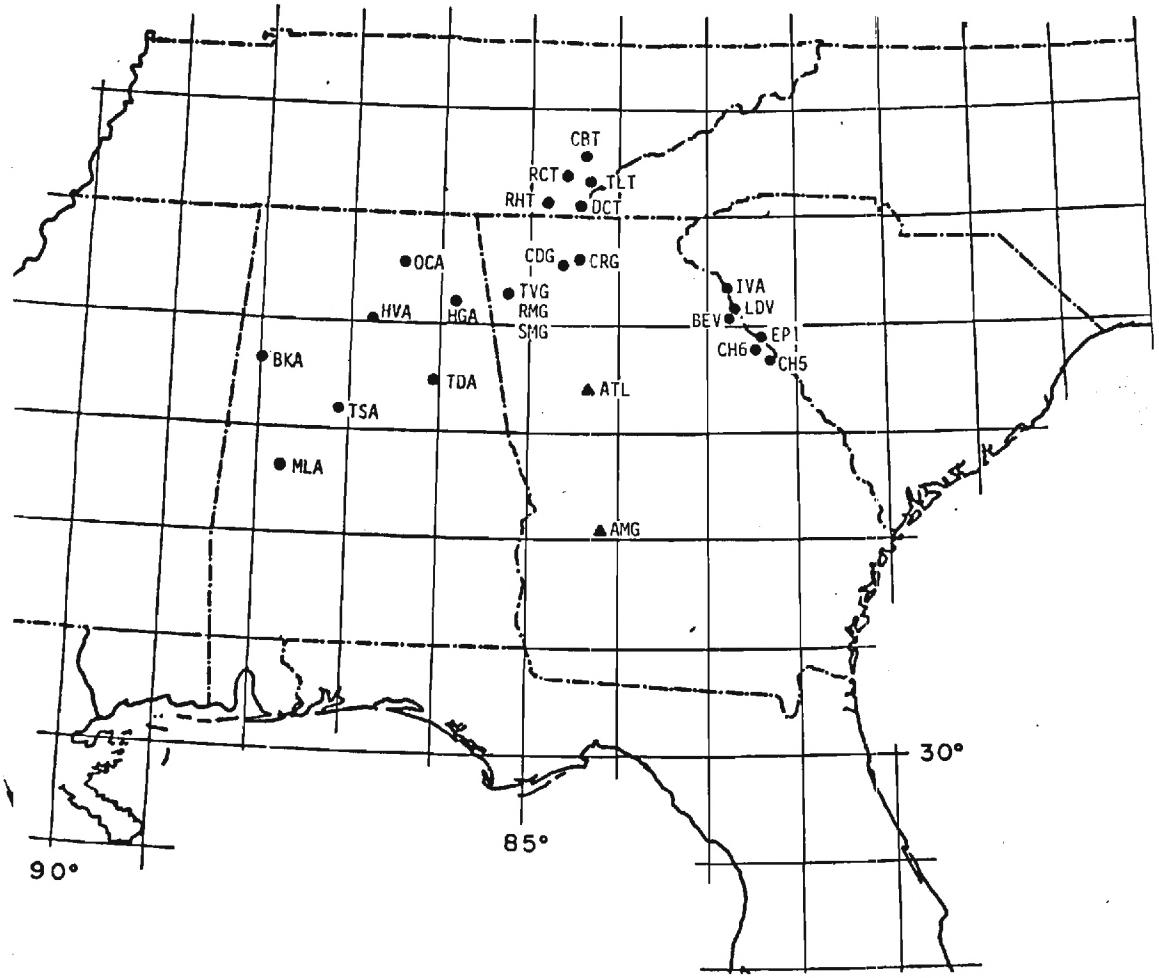

Figure 1. Seismic stations maintained by Georgia Tech as of January 1983.

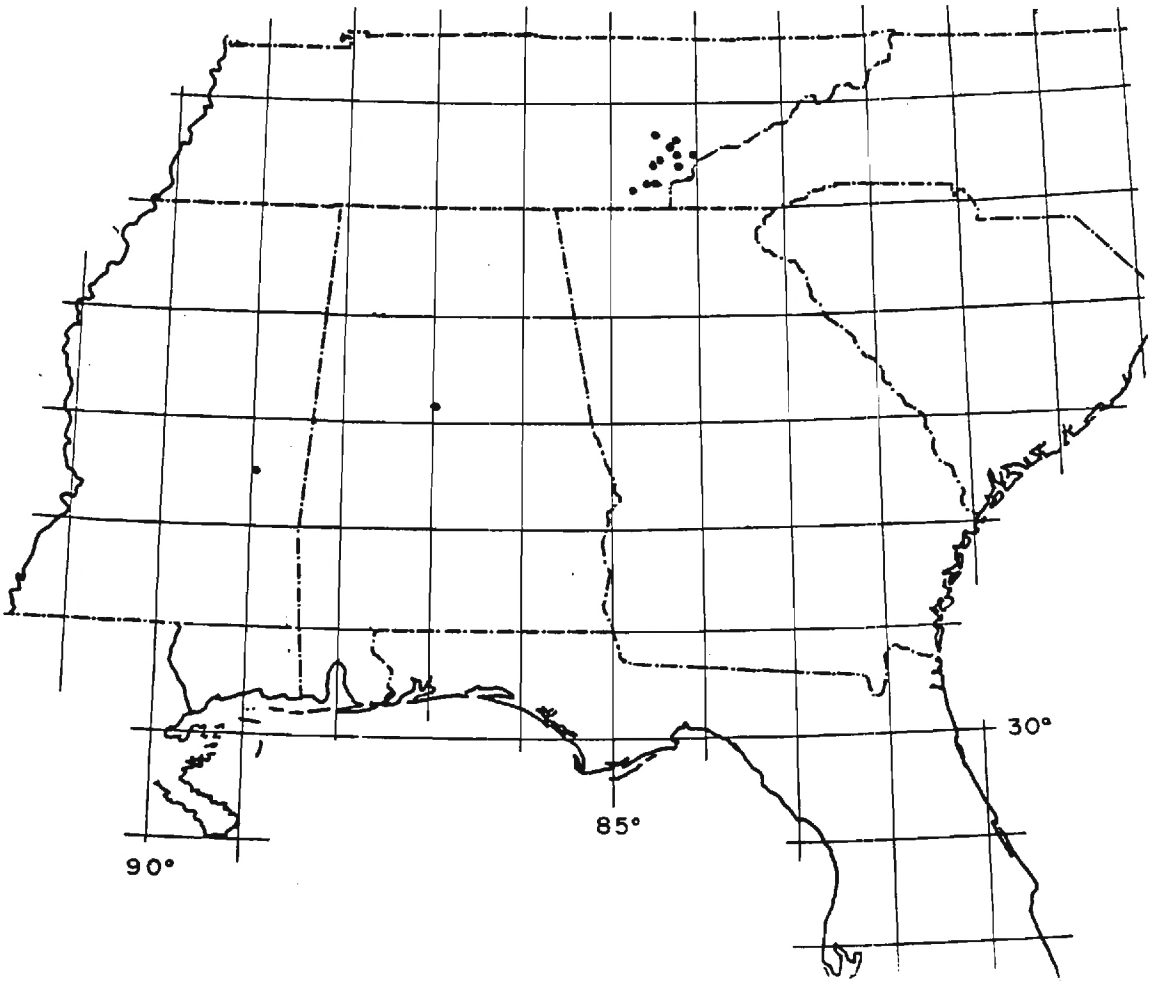

Figure 2. Epicenters from March 1, 1983 to May 31, 1983.

THE EVENT OCCURED ON MAR 4, 1983
AT ORIGIN TIME 14: 3:28.07 +/- .200
SWEETWATER, TENN
MAGNITUDE: 2.6
THE WEIGHTS ARE
WX= 1.000 WY= 1.000 WZ= 0.000 WT= 1.000
IT WAS LOCATED AT
LATITUDE 35.5870 +/- 1.315 KM. (35D,35.22M)
LONGITUDE 84.3083 +/- 1.550 KM. (84D,18.50M)

STATION	PHASE	HR	MIN	SEC	+OR-SEC	DIST	AZ	OBS-THE	THEOR.
RHT	PLG	14	3	40.20	.10	76.77	222.9	-.960	50621.16
HPK	PLG	14	3	37.10	.10	54.11	45.9	-.314	50617.41
TLT	PLG	14	3	33.80	.10	31.77	175.9	.078	50613.72
TLT	SLG	14	3	37.90	.20	31.77	175.9	-.295	50618.20
CBT	PG	14	3	30.90	.10	11.48	242.6	.743	50610.16
CBT	S	14	3	32.00	.20	11.48	242.6	.315	50611.69
DCT	PLG	14	3	38.40	.10	59.94	189.7	.023	50618.38
HPK	SLG	14	3	44.00	.20	54.11	45.9	-.470	50624.47
TKL	PLG	14	3	36.90	.10	49.03	80.7	.326	50616.57
TKL	SLG	14	3	43.70	.20	49.03	80.7	.658	50623.04

ERROR ELLIPSE IS AS FOLLOWS:
SEMIMINOR AXIS LENGTH = .9675 KM.
SEMIMAJOR AXIS LENGTH = 2.0918 KM.
AZIMUTH OF MAJOR AXIS = 127.7132 DEG.
AREA OF ELLIPSE = 6.3581 SQ.KM.
ECCENTRICITY = .8866

THE EVENT OCCURED ON MAR 11, 1983
AT ORIGIN TIME 22:29:40.25 +/- .140
SERVILLA, TENN
MAGNITUDE: 2.3
THE WEIGHTS ARE
WX= 1.000 WY= 1.000 WZ= 0.000 WT= 1.000
IT WAS LOCATED AT
LATITUDE 35.2326 +/- 1.574 KM. (35D,13.96M)
LONGITUDE 84.4782 +/- .370 KM. (84D,28.69M)

STATION	PHASE	HR	MIN	SEC	+OR-SEC	DIST	AZ	OBS-THE	THEOR
CBT	PLG	22	29	46.60	.10	34.43	8.7	.261	80986.34
CBT	SLG	22	29	50.90	.10	34.43	8.7	-.220	80991.12
TLT	PG	22	29	43.80	.10	19.31	66.8	.042	80983.76
DCT	PG	22	29	43.90	.10	20.51	164.8	-.077	80983.98
DCT	S	22	29	46.70	.10	20.51	164.8	-.006	80986.71

ERROR ELLIPSE IS AS FOLLOWS:
SEMIMINOR AXIS LENGTH = .5171 KM.
SEMIMAJOR AXIS LENGTH = 2.2269 KM.
AZIMUTH OF MAJOR AXIS = 2.0347 DEG.
AREA OF ELLIPSE = 3.6174 SQ.KM.
ECCENTRICITY = .9727

MEAN RESIDUAL : -.00000 STANDARD DEVIATION : .17613

THE EVENT OCCURED ON MAR 13, 1983
AT ORIGIN TIME 3:53:13.29 +/- .065
MADISONVILLE, TENN
MAGNITUDE: 2.0
THE WEIGHTS ARE
WX= 1.000 WY= 1.000 WZ= 0.000 WT= 1.000
IT WAS LOCATED AT
LATITUDE 35.4578 +/- 1.068 KM. (35D,27.47M)
LONGITUDE 84.3946 +/- .390 KM. (84D,23.68M)

STATION	PHASE	HR	MIN	SEC	+OR-SEC	DIST	AZ	OBS-THE	THEOR.
DCT	PLG	3	53	21.20	.10	44.83	182.9	.103	14001.10
DCT	SLG	3	53	26.90	.20	44.83	182.9	-.180	14007.08
CBT	PG	3	53	15.10	.10	9.36	345.4	.111	13994.99
CBT	S	3	53	16.00	.20	9.36	345.4	-.235	13996.23
TLT	PG	3	53	17.00	.10	20.12	149.8	.055	13996.94
TLT	S	3	53	19.50	.20	20.12	149.8	-.122	13999.62

ERROR ELLIPSE IS AS FOLLOWS:
SEMIMINOR AXIS LENGTH = .3636 KM.
SEMIMAJOR AXIS LENGTH = 1.4985 KM.
AZIMUTH OF MAJOR AXIS = 15.3103 DEG.
AREA OF ELLIPSE = 1.7117 SQ.KM.
ECCENTRICITY = .9701

MEAN RESIDUAL : -.04476 STANDARD DEVIATION : .15254

THE EVENT OCCURED ON MAR 16, 1983
AT ORIGIN TIME 9:13:51.63 +/- .149
RELIANCE, TENN
MAGNITUDE: 2.8
THE WEIGHTS ARE
WX= 1.000 WY= 1.000 WZ= 0.000 WT= 1.000
IT WAS LOCATED AT
LATITUDE 35.2102 +/- 1.137 KM. (35D,12.61M)
LONGITUDE 84.5611 +/- 1.170 KM. (84D,33.67M)

STATION	PHASE	HR	MIN	SEC	+OR-SEC	DIST	AZ
CBT	PLG	9	13	58.30	.10	38.70	19.2
CBT	SLG	9	14	3.00	.20	38.70	19.2
TLT	PLG	9	13	56.90	.10	27.23	68.2
TLT	SLG	9	13	59.90	.20	27.23	68.2
OCA	PLG	9	14	22.50	.10	183.01	249.0
DCT	PG	9	13	56.00	.10	21.59	143.2
RHT	PLG	9	13	57.20	.10	32.73	243.4
RHT	SLG	9	14	1.80	.20	32.73	243.4
TDA	PLG	9	14	29.00	.10	228.04	216.3
RCT	PG	9	13	55.50	.10	17.56	328.7
TDA	SLG	9	14	57.20	.20	228.04	216.3

ERROR ELLIPSE IS AS FOLLOWS:
SEMIMINOR AXIS LENGTH = .8716 KM.
SEMIMAJOR AXIS LENGTH = 1.6159 KM.
AZIMUTH OF MAJOR AXIS = 133.5184 DEG.
AREA OF ELLIPSE = 4.4247 SQ.KM.
ECCENTRICITY = .8420

THE EVENT OCCURED ON MAR 25 1983
AT ORIGIN TIME 2:47:12.81 +/- .221
S.C.-N.C. BORDER
MAGNITUDE: 3.3
THE WEIGHTS ARE
WX= 1.000 WY= 1.000 WZ= 0.000 WT= 1.000
IT WAS LOCATED AT
LATITUDE 35.1568 +/- 1.190 KM. (35D, 9.41M)
LONGITUDE 82.6811 +/- 1.724 KM. (82D,40.87M)

STATION	PHASE	HR	MIN	SEC	+OR-SEC	DIST	AZ	OBS-THE	THEOR.
RCT	PLG	2	47	43.50	.10	181.64	276.6	.265	10063.23
CDG	S-P	0	0	25.80	.20	190.78	251.6	.408	25.39
TLT	PLG	2	47	38.00	.10	146.85	276.3	.515	10057.49
CBT	PLG	2	47	40.00	.10	164.07	285.1	-.332	10060.33
RHT	PLG	2	47	46.00	.10	200.76	267.5	-.396	10066.40
RHT	S-P	0	0	26.20	.20	200.76	267.5	-.522	26.72
CH5	PLG	2	47	39.80	.10	161.44	167.8	-.095	10059.90
CBT	S-P	0	0	22.00	.20	164.07	285.1	.161	21.84
DCT	S-P	0	0	20.80	.20	158.79	265.9	-.335	21.13
DCT	PLG	2	47	39.50	.10	158.79	265.9	.042	10059.46
BEV	S-P	0	0	16.00	.20	118.49	182.3	.228	15.77

ERROR ELLIPSE IS AS FOLLOWS:
SEMIMINOR AXIS LENGTH = 1.1855 KM.
SEMIMAJOR AXIS LENGTH = 2.0199 KM.
AZIMUTH OF MAJOR AXIS = 68.2997 DEG.
AREA OF ELLIPSE = 7.5229 SQ.KM.
ECCENTRICITY = .8097

MEAN RESIDUAL : -.00541 STANDARD DEVIATION : .35228

THE EVENT OCCURED ON MAR 30, 1983
AT ORIGIN TIME 11:52:14.09 +/- .156
ATHENS, TENN
MAGNITUDE: 2.1
THE WEIGHTS ARE
WX= 1.000 WY= 1.000 WZ= 1.000 WT= 1.000
IT WAS LOCATED AT
LATITUDE 35.4114 +/- .474 KM. (35D,24.68M)
LONGITUDE 84.5075 +/- .473 KM. (84D,30.45M)
DEPTH 6.80 +/- 1.441 KM.

STATION	PHASE	HR	MIN	SEC	+OR-SEC	DIST	AZ	OBS-THE	THEOR.
CBT	PG	11	52	17.20	.10	17.75	29.0	-.122	42737.32
CBT	S	11	52	19.70	.20	17.75	29.0	.014	42739.69
DCT	PLG	11	52	21.00	.10	40.42	168.5	-.174	42741.17
TLT	S	11	52	21.60	.20	24.86	121.0	-.323	42741.92
RCT	S	11	52	19.60	.20	17.29	242.3	.060	42739.54
RCT	PG	11	52	17.20	.10	17.29	242.3	-.038	42737.24
TLT	PG	11	52	19.00	.10	24.86	121.0	.386	42738.61
ETT	PG	11	52	16.60	.10	12.93	153.2	.155	42736.44
ETT	S	11	52	18.00	.20	12.93	153.2	-.165	42738.17

ERROR ELLIPSE IS AS FOLLOWS:
SEMIMINOR AXIS LENGTH = .5610 KM.
SEMIMAJOR AXIS LENGTH = .6418 KM.
AZIMUTH OF MAJOR AXIS = 135.6350 DEG.
AREA OF ELLIPSE = 1.1312 SQ.KM.
ECCENTRICITY = .4857

THE EVENT OCCURED ON APR 5, 1983
AT ORIGIN TIME 0:41:20.97 +/- .223
MARVEL,ALABAMA
MAGNITUDE: 2.9
THE WEIGHTS ARE
WX= 1.000 WY= 1.000 WZ= 0.000 WT= 1.000
IT WAS LOCATED AT
LATITUDE 33.1691 +/- 1.201 KM. (33D,10.15M)
LONGITUDE 86.9896 +/- 1.214 KM. (86D,59.38M)

STATION	PHASE	HR	MIN	SEC	+OR-SEC	DIST	AZ	OBS-THE	THEOR.
OCA	PLG	0	41	48.90	.10	168.35	17.6	-.293	2509.19
OCA	SLG	0	42	9.50	.20	168.35	17.6	.044	2529.46
MLA	PLG	0	41	35.20	.10	83.39	232.1	.050	2495.15
TSA	PG	0	41	22.80	.10	12.07	323.0	-.361	2483.16
TSA	S	0	41	25.40	.20	12.07	323.0	.632	2484.77
TDA	PLG	0	41	38.00	.10	99.03	65.2	.266	2497.73

ERROR ELLIPSE IS AS FOLLOWS:
SEMIMINOR AXIS LENGTH = 1.4955 KM.
SEMIMAJOR AXIS LENGTH = 1.6623 KM.
AZIMUTH OF MAJOR AXIS = 132.1511 DEG.
AREA OF ELLIPSE = 7.8097 SQ.KM.
ECCENTRICITY = .4366

MEAN RESIDUAL : .05630 STANDARD DEVIATION : .36637

THE EVENT OCCURED ON APR 5, 1983
AT ORIGIN TIME 3:17:59.17 +/- .121
GREENBACK, TENN
MAGNITUDE: 2.2
THE WEIGHTS ARE
WX= 1.000 WY= 1.000 WZ= 0.000 WT= 1.000
IT WAS LOCATED AT
LATITUDE 35.5394 +/- .776 KM. (35D,32.36M)
LONGITUDE 84.1705 +/- .779 KM. (84D,10.23M)

STATION	PHASE	HR	MIN	SEC	+OR-SEC	DIST	AZ	OBS-THE	THEOR.
TLT	PLG	3	18	4.90	.10	28.34	201.2	.650	11884.25
TLT	SLG	3	18	8.50	.20	28.34	201.2	.173	11888.33
RHT	PLG	3	18	13.00	.20	82.38	231.8	-.183	11893.18
RHT	SLG	3	18	22.80	.50	82.38	231.8	-.707	11903.51
ETT	PLG	3	18	5.68	.10	35.01	227.5	.327	11885.35
ETT	SLG	3	18	10.21	.20	35.01	227.5	.009	11890.20
TKL	PLG	3	18	6.20	.10	38.27	69.8	.309	11885.89
TKL	SLG	3	18	11.42	.20	38.27	69.8	.304	11891.12
HPK	PLG	3	18	8.00	.10	50.38	31.5	.107	11887.89
HPK	SLG	3	18	14.00	.20	50.38	31.5	-.517	11894.52
BHT	PLG	3	18	12.40	.10	78.09	296.0	-.073	11892.47
BHT	SLG	3	18	21.90	.20	78.09	296.0	-.402	11902.30
BBG	PLG	3	18	12.40	.10	80.68	156.0	-.501	11892.90
BBG	SLG	3	18	22.29	.20	80.68	156.0	-.739	11903.03

ERROR ELLIPSE IS AS FOLLOWS:
SEMIMINOR AXIS LENGTH = .6979 KM.
SEMIMAJOR AXIS LENGTH = 1.0029 KM.
AZIMUTH OF MAJOR AXIS = 134.6535 DEG.
AREA OF ELLIPSE = 2.1988 SQ.KM.
ECCENTRICITY = .7182

MEAN RESIDUAL : -.08878 STANDARD DEVIATION : .43087

THE EVENT OCCURED ON APR 16, 1983
AT ORIGIN TIME 7:26:43.41 +/- .269
E. OF BELLTOWN, TENN
MAGNITUDE: 2.2
THE WEIGHTS ARE
WX= 1.000 WY= 1.000 WZ= 0.000 WT= 1.000
IT WAS LOCATED AT
LATITUDE 35.4090 +/- 1.463 KM. (35D,24.54M)
LONGITUDE 84.1923 +/- 1.604 KM. (84D,11.54M)

STATION	PHASE	HR	MIN	SEC	+OR-SEC	DIST	AZ	OBS-THE	THEOR.
DCT	PLG	7	26	50.50	.10	44.43	207.8	-.656	26811.16
DCT	SLG	7	26	55.70	.10	44.43	207.8	-1.393	26817.09
TLT	PG	7	26	45.90	.10	14.55	214.7	-.158	26806.06
TLT	S	7	26	47.00	.10	14.55	214.7	-.994	26807.99
RCT	PLG	7	26	51.20	.10	43.19	260.6	.249	26810.95
RCT	SLG	7	26	56.80	.10	43.19	260.6	.056	26816.74
CBT	PLG	7	26	48.40	.10	25.29	304.9	.408	26807.99
CBT	SLG	7	26	51.20	.10	25.29	304.9	-.515	26811.72
ETT	PLG	7	26	48.40	.10	25.57	248.9	.361	26808.04
ETT	SLG	7	26	53.50	.10	25.57	248.9	1.704	26811.80
TKL	PLG	7	26	51.50	.10	46.97	53.9	-.076	26811.58
TKL	SLG	7	26	57.20	.10	46.97	53.9	-.606	26817.81
BBG	PLG	7	26	55.40	.10	68.71	149.6	.231	26815.17
BBG	SLG	7	27	5.30	.10	68.71	149.6	1.388	26823.91

ERROR ELLIPSE IS AS FOLLOWS:
SEMIMINOR AXIS LENGTH = 1.5314 KM.
SEMIMAJOR AXIS LENGTH = 1.7962 KM.
AZIMUTH OF MAJOR AXIS = 117.2267 DEG.
AREA OF ELLIPSE = 8.6414 SQ.KM.
ECCENTRICITY = .5226

MEAN RESIDUAL : .00003 STANDARD DEVIATION : .84433

HE EVENT OCCURED ON MAY 16, 1983
AT ORIGIN TIME 6:50:23.47 +/- .141
GREENBECK, TENN
MAGNITUDE: 2.1
THE WEIGHTS ARE
WX= 1.000 WY= 1.000 WZ= 0.000 WT= 1.000
IT WAS LOCATED AT
LATITUDE 35.5398 +/- .935 KM. (35D,32.39M)
LONGITUDE 84.0572 +/- .977 KM. (84D, 3.43M)

STATION	PHASE	HR	MIN	SEC	+OR-SEC	DIST	AZ	OBS-THE	THEOR
RCT	PLG	6	50	33.60	.10	58.88	248.6	-.006	24633.61
RCT	SLG	6	50	40.80	.20	58.88	248.6	-.414	24641.21
CBT	PLG	6	50	29.60	.10	32.95	269.9	.280	24629.32
CBT	SLG	6	50	34.00	.10	32.95	269.9	.070	24633.93
DCT	PLG	6	50	34.20	.10	63.09	211.5	-.101	24634.30
DCT	SLG	6	50	41.90	.20	63.09	211.5	-.495	24642.39
TLT	PLG	6	50	29.80	.10	33.49	217.8	.392	24629.41
TLT	SLG	6	50	34.10	.20	33.49	217.8	.020	24634.08
HPK	PLG	6	50	31.20	.10	45.79	20.6	-.242	24631.44
HPK	SLG	6	50	36.30	.20	45.79	20.6	-1.236	24637.54
ETT	PLG	6	50	31.30	.10	43.17	236.7	.291	24631.01
ETT	SLG	6	50	36.90	.20	43.17	236.7	.100	24636.80
TKL	PLG	6	50	28.90	.10	28.83	62.9	.262	24628.64
TKL	SLG	6	50	33.80	.20	28.83	62.9	1.029	24632.77
BBG	PLG	6	50	36.50	.10	77.15	163.0	-.126	24636.63
BBG	SLG	6	50	45.70	.20	77.15	163.0	-.646	24646.35

ERROR ELLIPSE IS AS FOLLOWS:
SEMIMINOR AXIS LENGTH = .7511 KM.
SEMIMAJOR AXIS LENGTH = 1.2529 KM.
AZIMUTH OF MAJOR AXIS = 132.3535 DEG.
AREA OF ELLIPSE = 2.9566 SQ.KM.
ECCENTRICITY = .8004

THE EVENT OCCURED ON MAY 25, 1983
AT ORIGIN TIME 10:46: 6.71 +/- .299
N. OF SWEETWATER, TENN
MAGNITUDE: 2.1
THE WEIGHTS ARE
WX= 1.000 WY= 1.000 WZ= 0.000 WT= 1.000
IT WAS LOCATED AT
LATITUDE 35.6992 +/- 1.049 KM. (35D,41.95M)
LONGITUDE 84.4555 +/- 1.367 KM. (84D,27.33M)

STATION	PHASE	HR	MIN	SEC	+OR-SEC	DIST	AZ	OBS-THE	THEOR
TLT	PLG	10	46	14.70	.10	46.83	160.5	-.151	38774.85
TLT	SLG	10	46	21.20	.20	46.83	160.5	.134	38781.07
DCT	PLG	10	46	19.20	.10	71.62	177.4	.251	38778.95
DCT	SLG	10	46	27.80	.20	71.62	177.4	-.230	38788.03
RCT	PLG	10	46	14.20	.10	43.45	205.5	-.093	38774.29
RCT	SLG	10	46	20.20	.20	43.45	205.5	.093	38780.12

ERROR ELLIPSE IS AS FOLLOWS:
SEMIMINOR AXIS LENGTH = 1.3459 KM.
SEMIMAJOR AXIS LENGTH = 1.7717 KM.
AZIMUTH OF MAJOR AXIS = 82.2744 DEG.
AREA OF ELLIPSE = 7.4913 SQ.KM.
ECCENTRICITY = .6503

THE EVENT OCCURED ON MAY 26, 1983
AT ORIGIN TIME 12:30: 1.99 +/- .163
GREENBECK, TENN
MAGNITUDE: 2.8
THE WEIGHTS ARE
WX= 1.000 WY= 1.000 WZ= 0.000 WT= 1.000
IT WAS LOCATED AT
LATITUDE 35.6517 +/- .704 KM. (35D,39.10M)
LONGITUDE 84.2507 +/- .934 KM. (84D,15.04M)

STATION	PHASE	HR	MIN	SEC	+OR-SEC	DIST	AZ	OBS-THE	THEOR
TLT	PLG	12	30	9.40	.10	39.01	184.4	.566	45009.83
DCT	PLG	12	30	14.20	.10	68.02	193.1	.571	45013.63
DCT	SLG	12	30	22.20	.20	68.02	193.1	-.093	45022.29
RCT	PLG	12	30	10.80	.10	50.38	227.7	.087	45010.71
RCT	SLG	12	30	17.50	.20	50.38	227.7	.162	45017.34
CDG	SLG	12	30	37.00	.20	121.45	198.3	-.302	45037.30
TVG	SLG	12	30	50.80	.50	170.46	214.4	-.267	45051.07
BEV	PLG	12	30	38.20	.10	221.16	141.1	-.742	45038.94
BEV	SLG	12	31	4.80	.20	221.16	141.1	-.511	45065.31
BHT	PLG	12	30	13.20	.10	66.49	289.1	-.177	45013.38
BHT	SLG	12	30	21.30	.20	66.49	289.1	-.564	45021.86
BBG	PLG	12	30	17.60	.10	95.02	155.0	-.492	45018.09
ETT	PLG	12	30	9.40	.10	40.59	207.2	.305	45009.10
ETT	SLG	12	30	14.60	.20	40.59	207.2	.012	45014.59
TKL	PLG	12	30	10.00	.10	43.16	89.1	.479	45009.52
TKL	SLG	12	30	15.50	.20	43.16	89.1	.189	45015.31

ERROR ELLIPSE IS AS FOLLOWS:
SEMIMINOR AXIS LENGTH = .7578 KM.
SEMIMAJOR AXIS LENGTH = 1.0142 KM.
AZIMUTH OF MAJOR AXIS = 96.9217 DEG.
AREA OF ELLIPSE = 2.4147 SQ.KM.
ECCENTRICITY = .6646

MEAN RESIDUAL : -.04847 STANDARD DEVIATION : .41438

THE EVENT OCCURED ON MAY 30, 1983
AT ORIGIN TIME 7:14: 3.86 +/- .672
QUITMAN, MISS
MAGNITUDE: 2.7
THE WEIGHTS ARE
WX= 1.000 WY= 1.000 WZ= 0.000 WT= 1.000
IT WAS LOCATED AT
LATITUDE 32.5357 +/- 2.460 KM. (32D,32.14M)
LONGITUDE 88.9518 +/- 2.961 KM. (88D,57.11M)

STATION	PHASE	HR	MIN	SEC	+OR-SEC	DIST	AZ	OBS-TME	THEOR.
HVA	PLG	7	14	47.70	.10	263.37	50.6	-.092	26007.79
HVA	SLG	7	15	18.00	.20	263.37	50.6	-1.041	26119.04
PWL	SLG	7	15	25.10	.20	283.61	16.6	.375	26124.72
TVG	PN	7	15	.90	.20	399.05	58.7	.839	26100.06
TVG	SN	7	15	42.50	.50	399.05	58.7	.986	26141.51
BKA	PLG	7	14	30.00	.10	152.82	36.8	.481	26069.52
BKA	SLG	7	14	48.00	.20	152.82	36.8	.014	26087.99
TSA	PLG	7	14	36.20	.10	194.20	65.5	-.159	26076.36
TSA	SLG	7	14	59.60	.20	194.20	65.5	-.011	26099.61
EBZ	PLG	7	14	51.60	.10	271.35	352.8	-.816	26092.42
EBZ	SLG	7	15	27.50	.20	271.35	352.8	.601	26126.90

ERROR ELLIPSE IS AS FOLLOWS:
SEMIMINOR AXIS LENGTH = 2.2826 KM.
SEMIMAJOR AXIS LENGTH = 3.7265 KM.
AZIMUTH OF MAJOR AXIS = 56.9066 DEG.
AREA OF ELLIPSE = 26.7227 SQ.KM.
ECCENTRICITY = .7904

MEAN RESIDUAL : .10705 STANDARD DEVIATION : .63777

GEORGIA INSTITUTE OF TECHNOLOGY

QUARTERLY EARTHQUAKE BULLETIN

1 June 1983 - 31 August 1983

By

Leland Timothy Long, Anton M. Dainty, Jeffrey K. Wilson,

Anthony P. Johnson, Jeih-San Liow, Robert M. Duckworth,

An Tie, and Russell L. Propes

School of Geophysical Sciences

Earth Sciences Division

Supported by:

Alabama Geological Survey
(through contract with U.S. Nuclear Regulatory Commission)

Georgia Power Company

U.S. Army Corps of Engineers
(Savannah District)

U.S. Geological Survey
(Contract No. 14-08-0001-21241)

Tennessee Valley Authority

U.S. Army Corps of Engineers
(Mobile District)

QUARTERLY EARTHQUAKE BULLETIN

1 June 1983 - 31 August 1983

The information presented in this bulletin includes the origin times, magnitudes, hypocentral coordinates and their precision, and the arrival times of selected phases for local earthquakes recorded by seismic stations maintained by Georgia Tech, School of Geophysical Sciences.

The network consists of 23 seismic stations located in Alabama, southeast Tennessee, Georgia, and South Carolina monitored by the School of Geophysical Sciences at Georgia Tech. Additional seismogram readings were obtained from stations operated by the Tennessee Valley Authority and the Tennessee Earthquake Information Center. The coordinates of the stations used in locating the events are given in Table 1. A map of the seismic stations maintained by Georgia Tech is given in Figure 1. Bollinger and Mathena (1983) describe the instrumentation of the seismic network and magnitude threshold.

The events are located using a computer program with techniques similar to those used in HYP071 but is more flexible in assigning weights and utilizing phases.

Magnitudes are defined by their duration according to the equation:

$$m_b(Lg)_{Dur} = -1.7 + 2.21 \log_{10} T ,$$

where T is the mean signal duration in seconds (Chaplin, Taylor, and Toksoz, 1980). A map showing the epicenters can be seen in Figure 2 and is followed by data sheets containing information and individual events that occurred during the quarter.

References

Bollinger, G. A., and E. Mathena (1983). Seismicity of the southeastern United States, Southeastern U.S. Network Bulletin, 11, May 1983.

Chaplin, M. P., S. R. Taylor, and M. N. Toksõz (1980). A coda-length magnitude scale for New England, Earthquake Notes, 51, No. 4, 15-22.

Table 1. Coordinates of stations used in locating the events in this report.

STA	Latitude	Longitude
BBG	34.8740	83.8110
BEV	34.0893	82.7334
BHT	35.8470	84.9450
BKA	33.6339	87.9690
CDG	34.6108	84.6667
CH5	33.7332	82.3118
CH6	33.8938	82.5291
DCT	35.0542	84.4194
EBZ	35.1410	89.3510
ETT	35.3260	84.4550
HGA	34.2602	85.8464
HPK	35.9260	83.8790
LDV	34.1479	82.6833
MLA	32.7055	87.6936
OCA	34.6138	86.4352
PGM	34.4640	90.1130
PWL	34.9800	88.0640
RCT	35.3453	84.6614
RMG	34.3359	85.3160
TDA	33.5417	86.0247
TLT	35.3011	84.2833
TKL	35.6581	83.7742
TVG	34.3771	85.3023

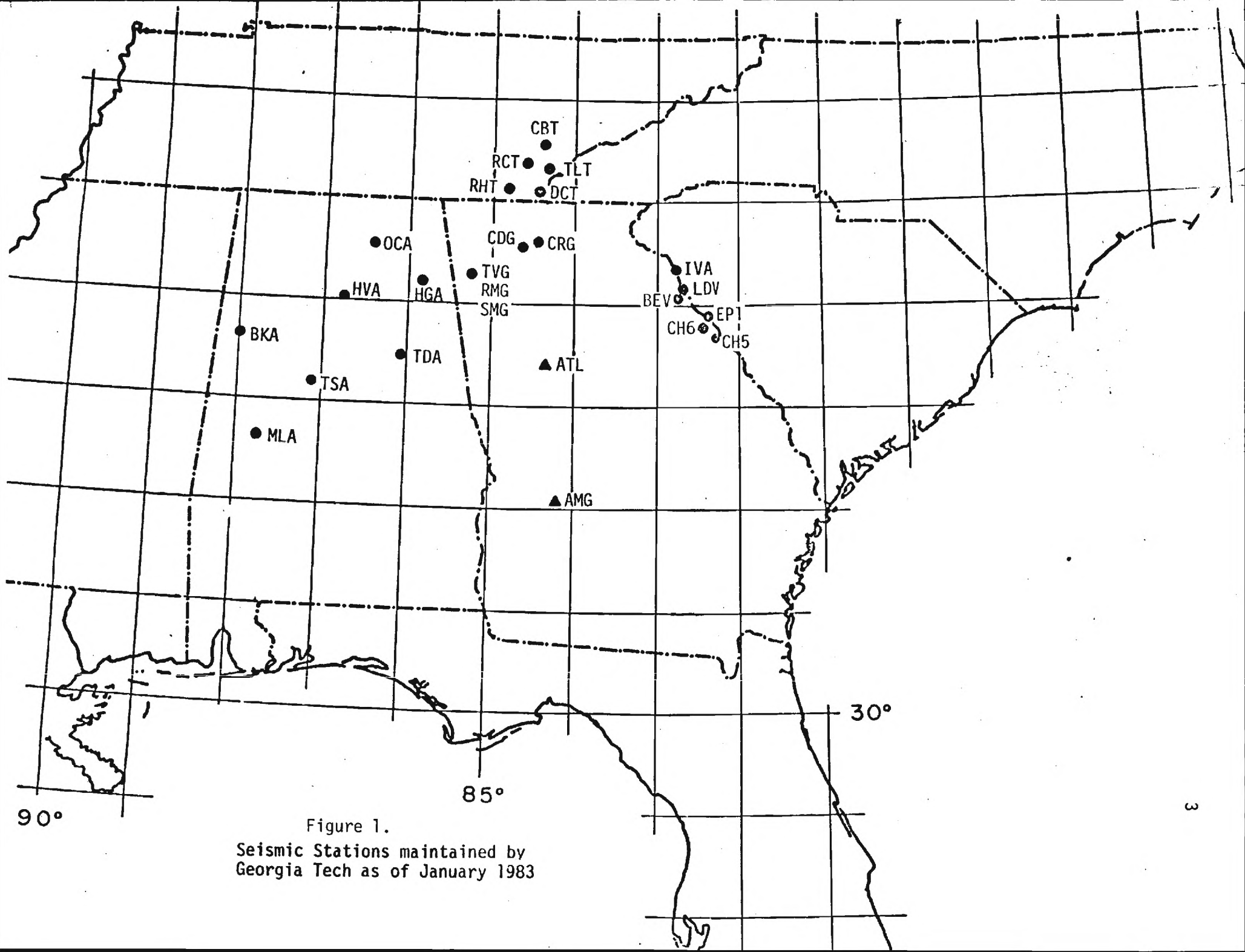

Figure 1.
Seismic Stations maintained by
Georgia Tech as of January 1983

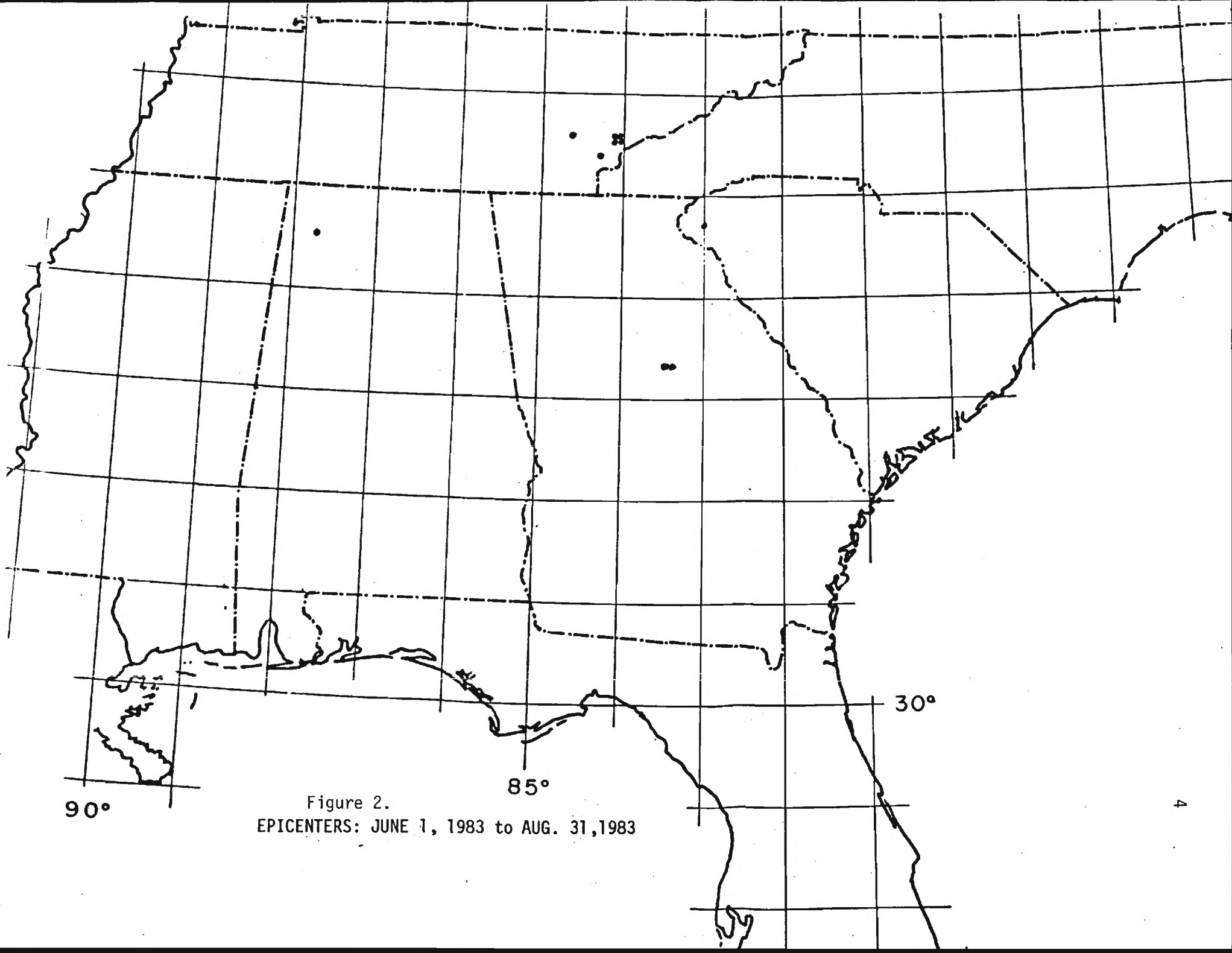

Figure 2.
EPICENTERS: JUNE 1, 1983 to AUG. 31,1983

THE EVENT OCCURED ON JUN 17, 1983
AT ORIGIN TIME 4:11: 8.78 +/- .540
NE OF MACON, GA
MAGNITUDE: 2.5
THE WEIGHTS ARE
WX= 1.000 WY= 1.000 WZ= 0.000 WT= 1.000
IT WAS LOCATED AT
LATITUDE 33.3626 +/- 1.359 KM. (33D,21.75M)
LONGITUDE 83.4683 +/- 3.560 KM. (83D,28.10M)

STATION	PHASE	HR	MIN	SEC	+OR-SEC	DIST	AZ	OBS-THE	THEOR.	DT
TVG	PLG	4	11	43.60	.10	204.44	303.7	.631	15102.97	-.
CH6	SLG	4	11	40.00	.20	105.41	55.9	.412	15099.59	.
DCT	PLG	4	11	42.60	.10	207.45	335.2	-.867	15103.47	-.
DCT	SLG	4	12	8.60	.20	207.45	335.2	.350	15128.25	-.
CH5	SLG	4	11	42.70	.20	115.21	69.0	.358	15102.34	.
CH5	PLG	4	11	28.00	.10	115.21	69.0	-.222	15088.22	.
CH6	PLG	4	11	26.50	.10	105.41	55.9	-.101	15086.60	.

ERROR ELLIPSE IS AS FOLLOWS:
SEMIMINOR AXIS LENGTH = 1.5077 KM.
SEMIMAJOR AXIS LENGTH = 4.4861 KM.
AZIMUTH OF MAJOR AXIS = 79.6665 DEG.
AREA OF ELLIPSE = 21.2488 SQ.KM.
ECCENTRICITY = .9418

MEAN RESIDUAL : .08000 STANDARD DEVIATION : .51395

THE EVENT OCCURED ON JUN 17, 1983
AT ORIGIN TIME 11:23:15.03 +/- .446
NE OF MACON, GA
MAGNITUDE: 2.5
THE WEIGHTS ARE
WX= 1.000 WY= 1.000 WZ= 0.000 WT= 1.000
IT WAS LOCATED AT
LATITUDE 33.2695 +/- 1.031 KM. (33D,16.17M)
LONGITUDE 83.4575 +/- 2.677 KM. (83D,27.45M)

STATION	PHASE	HR	MIN	SEC	+OR-SEC	DIST	AZ	OBS-THE	THEOR.
DCT	PLG	11	23	51.20	.10	217.27	336.1	-.141	41031.34
DCT	SLG	11	24	17.10	.20	217.27	336.1	-.160	41057.26
TLT	PLG	11	23	53.90	.20	238.09	341.6	-.882	41034.78
TLT	SLG	11	24	23.00	.50	238.09	341.6	-.108	41063.11
TVG	PLG	11	23	50.80	.10	211.25	305.9	.453	41030.35
TVG	SLG	11	24	15.90	.20	211.25	305.9	.331	41055.57
CH5	PLG	11	23	34.80	.10	118.48	64.2	-.213	41015.01
CH5	SLG	11	23	49.70	.20	118.48	64.2	.189	41029.51
CH6	PLG	11	23	33.50	.10	110.79	51.1	-.241	41013.74
CH6	SLG	11	23	48.20	.20	110.79	51.1	.850	41027.35

ERROR ELLIPSE IS AS FOLLOWS:
SEMIMINOR AXIS LENGTH = 1.0580 KM.
SEMIMAJOR AXIS LENGTH = 3.0762 KM.
AZIMUTH OF MAJOR AXIS = 80.0562 DEG.
AREA OF ELLIPSE = 10.2245 SQ.KM.
ECCENTRICITY = .9390

MEAN RESIDUAL : .00776 STANDARD DEVIATION : .47281

THE EVENT OCCURED ON JUN 22, 1983
AT ORIGIN TIME 5:53:25.47 +/- .261
W. OF SWEETWATER, TENN
MAGNITUDE: 2.0
THE WEIGHTS ARE
WX= 1.000 WY= 1.000 WZ= 0.000 WT= 1.000
IT WAS LOCATED AT
LATITUDE 35.6145 +/- .786 KM. (35D,36.87M)
LONGITUDE 84.6510 +/- 1.152 KM. (84D,39.06M)

STATION	PHASE	HR	MIN	SEC	+OR-SEC	DIST	AZ	OBS-THE	THEOR.	DT/
RCT	PLG	5	53	30.80	.10	29.88	181.8	-.009	21210.81	-.
RCT	SLG	5	53	35.20	.20	29.88	181.8	.137	21215.06	-.
DCT	PLG	5	53	36.70	.10	65.60	161.2	-.013	21216.71	.
DCT	SLG	5	53	44.90	.20	65.60	161.2	-.198	21225.10	.
TLT	SLG	5	53	40.30	.20	48.15	136.1	.104	21220.20	.

ERROR ELLIPSE IS AS FOLLOWS:
SEMIMINOR AXIS LENGTH = 1.1095 KM.
SEMIMAJOR AXIS LENGTH = 1.6319 KM.
AZIMUTH OF MAJOR AXIS = 93.6607 DEG.
AREA OF ELLIPSE = 5.6885 SQ.KM.
ECCENTRICITY = .7333

MEAN RESIDUAL : .00433 STANDARD DEVIATION : .13104

THE EVENT OCCURED ON JUN 26, 1983
AT ORIGIN TIME 17:34: 2.76 +/- .139
TELLICO PLAINS, TENN
MAGNITUDE: 2.1
THE WEIGHTS ARE
WX= 1.000 WY= 1.000 WZ= 0.000 WT= 1.000
IT WAS LOCATED AT
LATITUDE 35.4000 +/- .727 KM. (35D,24.00M)
LONGITUDE 84.3041 +/- .920 KM. (84D,18.25M)

STATION	PHASE	HR	MIN	SEC	+OR-SEC	DIST	AZ	OBS-THE	THEOR.	DT/
RCT	SLG	17	34	12.70	.20	33.02	259.4	-.540	63253.24	-.
TKL	SLG	17	34	19.80	.20	56.01	59.2	.104	63259.70	.
TLT	PG	17	34	4.70	.10	11.15	170.2	-.091	63244.79	.
TLT	S	17	34	6.20	.20	11.15	170.2	-.075	63246.27	.
ETT	PLG	17	34	5.90	.10	15.98	239.1	.094	63245.81	-.
ETT	SLG	17	34	9.00	.20	15.98	239.1	.547	63248.45	-.
TKL	PLG	17	34	12.40	.10	56.01	59.2	-.021	63252.42	.

ERROR ELLIPSE IS AS FOLLOWS:
SEMIMINOR AXIS LENGTH = .7586 KM.
SEMIMAJOR AXIS LENGTH = 1.2195 KM.
AZIMUTH OF MAJOR AXIS = 119.2686 DEG.
AREA OF ELLIPSE = 2.9064 SQ.KM.
ECCENTRICITY = .7829

MEAN RESIDUAL : .00257 STANDARD DEVIATION : .32255

THE EVENT OCCURED ON JUL 2, 1983
AT ORIGIN TIME 6:46:28.62 +/- .172
GREENBECK, TENN
MAGNITUDE: 2.2
THE WEIGHTS ARE
WX= 1.000 WY= 1.000 WZ= 0.000 WT= 1.000
IT WAS LOCATED AT
LATITUDE 35.6420 +/- 1.120 KM. (35D,38.52M)
LONGITUDE 84.1441 +/- 1.189 KM. (84D, 8.65M)

STATION	PHASE	HR	MIN	SEC	+OR-SEC	DIST	AZ	OBS-THE	THEOR.	D
RCT	PLG	6	46	38.10	.10	57.25	235.0	-.380	24398.48	-
RCT	SLG	6	46	44.80	.20	57.25	235.0	-1.099	24405.90	-
TVG	PLG	6	46	58.00	.10	175.18	217.2	.029	24417.97	-
TVG	SLG	6	47	19.00	.20	175.18	217.2	-.023	24439.02	-
DCT	PLG	6	46	41.00	.10	69.80	201.1	.446	24400.55	-
DCT	SLG	6	46	49.50	.20	69.80	201.1	.076	24409.42	-
ETT	PLG	6	46	36.20	.10	44.96	218.9	-.248	24396.45	-
ETT	SLG	6	46	42.40	.20	44.96	218.9	-.046	24402.45	-
TKL	PLG	6	46	34.80	.10	33.55	86.9	.239	24394.56	
TKL	SLG	6	46	39.50	.20	33.55	86.9	.260	24399.24	
HPK	PLG	6	46	35.50	.10	39.61	37.2	-.064	24395.56	
HPK	SLG	6	46	39.90	.20	39.61	37.2	-1.044	24400.94	
BHT	PLG	6	46	42.60	.10	76.02	287.5	1.019	24401.58	-
BBG	SLG	6	46	55.70	.20	90.37	160.3	.499	24415.20	
BBG	PLG	6	46	43.60	.10	90.37	160.3	-.353	24403.95	

ERROR ELLIPSE IS AS FOLLOWS:
SEMIMINOR AXIS LENGTH = .8502 KM.
SEMIMAJOR AXIS LENGTH = 1.5535 KM.
AZIMUTH OF MAJOR AXIS = 131.8443 DEG.
AREA OF ELLIPSE = 4.1493 SQ.KM.
ECCENTRICITY = .8370

MEAN RESIDUAL : -.04588 STANDARD DEVIATION : .54894

THE EVENT OCCURED ON JUL 7, 1983
AT ORIGIN TIME 7: 6:42.86 +/- .369
GA-S.C. BORDER - KEOWEE
MAGNITUDE: 2.7
THE WEIGHTS ARE
WX= 1.000 WY= 1.000 WZ= 0.000 WT= 1.000
IT WAS LOCATED AT
LATITUDE 34.5987 +/- 2.940 KM. (34D,35.92M)
LONGITUDE 83.0674 +/- 3.672 KM. (83D, 4.04M)

STATION	PHASE	HR	MIN	SEC	+OR-SEC	DIST	AZ	OBS-THE	THEOR.	D
LDV	PLG	7	6	53.10	.10	61.16	144.7	-.265	25613.36	
LDV	SLG	7	7	2.00	.20	61.16	144.7	.764	25621.24	
BEV	PLG	7	6	54.00	.10	64.27	151.4	.122	25613.88	
BEV	SLG	7	7	2.50	.20	64.27	151.4	.392	25622.11	
TVG	PLG	7	7	17.00	.20	206.48	263.2	-.384	25637.38	-
TVG	S-P	0	0	26.80	.20	206.48	263.2	-.682	27.48	-
DCT	PLG	7	7	6.00	.20	133.92	292.3	.609	25625.39	-
DCT	SLG	7	7	22.30	.20	133.92	292.3	.627	25641.67	-
CH5	PLG	7	7	2.20	.10	118.39	143.9	-.625	25622.82	
CH5	SLG	7	7	18.10	.20	118.39	143.9	.788	25637.31	
CH6	PLG	7	6	58.00	.10	92.47	147.5	-.539	25618.54	
RCT	SLG	7	7	30.80	.50	168.04	299.7	-.459	25651.26	-

ERROR ELLIPSE IS AS FOLLOWS:
SEMIMINOR AXIS LENGTH = .9320 KM.
SEMIMAJOR AXIS LENGTH = 5.1240 KM.
AZIMUTH OF MAJOR AXIS = 51.7568 DEG.
AREA OF ELLIPSE = 15.0023 SQ.KM.
ECCENTRICITY = .9833

MEAN RESIDUAL : .02907 STANDARD DEVIATION : .58000

THE EVENT OCCURED ON JUL 8, 1983
AT ORIGIN TIME 19:29: 5.47 +/- .161
TELLICO PLAINS, TENN
MAGNITUDE: 3.2
THE WEIGHTS ARE
WX= 1.000 WY= 1.000 WZ= 0.000 WT= 1.000
IT WAS LOCATED AT
LATITUDE 35.5274 +/- .674 KM. (35D,31.65M)
LONGITUDE 84.1337 +/- .981 KM. (84D, 8.02M)

STATION	PHASE	HR	MIN	SEC	+OR-SEC	DIST	AZ	OBS-THE	THEOR.	DT
BEV	PLG	19	29	39.00	.10	203.89	141.0	-.567	70179.57	.
BEV	SLG	19	30	3.70	.20	203.89	141.0	-.239	70203.94	.
TKL	PLG	19	29	12.20	.10	35.68	66.0	.437	70151.76	.
TKL	SLG	19	29	17.00	.20	35.68	66.0	.312	70156.69	.
CDG	PLG	19	29	24.80	.10	112.58	205.7	.326	70164.47	-.
CDG	SLG	19	29	38.00	.20	112.58	205.7	-.290	70178.29	-.
DCT	PLG	19	29	16.20	.10	58.54	206.4	.658	70155.54	-.
DCT	SLG	19	29	23.40	.20	58.54	206.4	.290	70163.11	-.
HGA	PLG	19	29	39.90	.10	209.49	228.3	-.592	70180.49	-.
HGA	SLG	19	30	5.60	.20	209.49	228.3	.089	70205.51	-.
RMG	PLG	19	29	33.50	.10	170.19	219.5	-.497	70174.00	-.
RMG	SLG	19	29	54.90	.50	170.19	219.5	.427	70194.47	-.
TVG	PLG	19	29	33.00	.10	165.87	220.1	-.283	70173.28	-.
TVG	SLG	19	29	53.00	.20	165.87	220.1	-.259	70193.26	-.
CH5	PLG	19	29	48.00	.10	258.66	139.7	-.619	70188.62	.
CH5	SLG	19	30	18.70	.20	258.66	139.7	-.623	70219.32	.
LDV	PLG	19	29	38.90	.10	201.78	138.8	-.318	70179.22	.
LDV	SLG	19	30	3.00	.20	201.78	138.8	-.346	70203.35	.
BBG	PLG	19	29	19.80	.10	78.17	157.9	1.014	70158.79	.
BBG	SLG	19	29	30.00	.20	78.17	157.9	1.377	70168.62	.
BHT	PLG	19	29	19.20	.10	81.68	295.8	-.166	70159.37	-.
BHT	SLG	19	29	29.00	.20	81.68	295.8	-.609	70169.61	-.
RCT	PLG	19	29	14.80	.10	51.95	247.2	.347	70154.45	-.
RCT	SLG	19	29	20.70	.20	51.95	247.2	-.559	70161.26	-.
ETT	PLG	19	29	12.30	.10	36.72	232.6	.364	70151.94	-.
ETT	SLG	19	29	17.00	.20	36.72	232.6	.019	70156.98	-.
CH6	PLG	19	29	43.80	.10	232.40	140.7	-.479	70184.28	.
OCA	PN	19	29	42.00	.10	232.04	244.4	.709	70181.29	-.

ERROR ELLIPSE IS AS FOLLOWS:
SEMIMINOR AXIS LENGTH = .7005 KM.
SEMIMAJOR AXIS LENGTH = 1.0197 KM.
AZIMUTH OF MAJOR AXIS = 89.7195 DEG.
AREA OF ELLIPSE = 2.2440 SQ.KM.
ECCENTRICITY = .7266

MEAN RESIDUAL : -.00279 STANDARD DEVIATION : .54164

THE EVENT OCCURED ON JUL 9, 1983
AT ORIGIN TIME 3:28:46.91 +/- .509
TENN
MAGNITUDE: 1.5
THE WEIGHTS ARE
WX= 1.000 WY= 1.000 WZ= 0.000 WT= 1.000
IT WAS LOCATED AT
LATITUDE 35.5210 +/- 2.341 KM. (35D,31.26M)
LONGITUDE 84.1100 +/- 3.706 KM. (84D, 6.60M)

STATION	PHASE	HR	MIN	SEC	+OR-SEC	DIST	AZ	OBS-THE	THEOR.	D
RCT	PLG	3	28	57.20	.10	53.68	248.7	1.015	12536.18	-
RCT	SLG	3	29	4.20	.20	53.68	248.7	1.009	12543.19	-
ETT	PLG	3	28	52.20	.10	38.04	235.4	-1.401	12533.60	-
ETT	SLG	3	28	58.10	.20	38.04	235.4	-.699	12538.80	-
TKL	SLG	3	28	57.60	.20	34.04	63.4	-.075	12537.67	
BBG	SLG	3	29	10.20	.20	76.73	159.1	.536	12547.66	

ERROR ELLIPSE IS AS FOLLOWS:
SEMIMINOR AXIS LENGTH = 2.6677 KM.
SEMIMAJOR AXIS LENGTH = 5.0072 KM.
AZIMUTH OF MAJOR AXIS = 109.8064 DEG.
AREA OF ELLIPSE = 41.9649 SQ.KM.
ECCENTRICITY = .8463

MEAN RESIDUAL : .06425 STANDARD DEVIATION : .97644

THE EVENT OCCURED ON JUL 9, 1983
AT ORIGIN TIME 9:57:47.95 +/- .229
TENN
MAGNITUDE: 1.7
THE WEIGHTS ARE
WX= 1.000 WY= 1.000 WZ= 0.000 WT= 1.000
IT WAS LOCATED AT
LATITUDE 35.4526 +/- 2.161 KM. (35D,27.16M)
LONGITUDE 84.0457 +/- 2.678 KM. (84D, 2.74M)

STATION	PHASE	HR	MIN	SEC	+OR-SEC	DIST	AZ	OBS-THE	THEOR.
RCT	PLG	9	57	58.50	.10	57.15	258.0	.706	35877.79
RCT	SLG	9	58	5.00	.20	57.15	258.0	-.200	35885.20
ETT	PLG	9	57	54.20	.10	39.72	249.3	-.714	35874.91
DCT	SLG	9	58	4.20	.20	55.71	217.6	-.597	35884.80
TKL	PLG	9	57	53.80	.10	33.57	47.2	-.098	35873.90
TKL	SLG	9	57	58.50	.20	33.57	47.2	-.079	35878.58
DCT	PLG	9	57	58.10	.10	55.71	217.6	.543	35877.56

ERROR ELLIPSE IS AS FOLLOWS:
SEMIMINOR AXIS LENGTH = 1.2532 KM.
SEMIMAJOR AXIS LENGTH = 4.0595 KM.
AZIMUTH OF MAJOR AXIS = 127.5849 DEG.
AREA OF ELLIPSE = 15.9824 SQ.KM.
ECCENTRICITY = .9512

THE EVENT OCCURED ON JUL 15, 1983
AT ORIGIN TIME 19:32:56.65 +/- .592
TENN
MAGNITUDE: 2.8
THE WEIGHTS ARE
WX= 1.000 WY= 1.000 WZ= 0.000 WT= 1.000
IT WAS LOCATED AT
LATITUDE 35.4846 +/- 1.292 KM. (35D,29.08M)
LONGITUDE 84.1195 +/- 3.599 KM. (84D, 7.17M)

STATION	PHASE	HR	MIN	SEC	+OR-SEC	DIST	AZ	OBS-THE	THEOR.
RCT	PLG	19	33	6.30	.10	51.55	252.6	.735	70385.57
RCT	SLG	19	33	13.40	.20	51.55	252.6	1.075	70392.32
DCT	PLG	19	33	6.30	.10	54.96	209.8	.171	70386.13
DCT	SLG	19	33	13.30	.20	54.96	209.8	.017	70393.28
TVG	PLG	19	33	24.30	.10	163.13	221.5	.291	70404.01
TVG	SLG	19	33	43.10	.20	163.13	221.5	-.568	70423.67
LDV	PLG	19	33	29.30	.10	197.40	138.2	-.373	70409.67
LDV	SLG	19	33	54.50	.20	197.40	138.2	1.205	70433.29
BEV	PLG	19	33	29.80	.10	199.43	140.4	-.209	70410.01
BEV	SLG	19	33	54.70	.20	199.43	140.4	.835	70433.86
CH6	PLG	19	33	34.00	.10	227.95	140.2	-.722	70414.72
CH6	SLG	19	34	1.60	.50	227.95	140.2	-.275	70441.88
ETT	PLG	19	33	2.30	.10	35.17	240.0	-.558	70382.86
ETT	SLG	19	33	6.60	.20	35.17	240.0	-1.123	70387.72

ERROR ELLIPSE IS AS FOLLOWS:
SEMIMINOR AXIS LENGTH = 1.2731 KM.
SEMIMAJOR AXIS LENGTH = 3.9631 KM.
AZIMUTH OF MAJOR AXIS = 80.8463 DEG.
AREA OF ELLIPSE = 15.8505 SQ.KM.
ECCENTRICITY = .9470

MEAN RESIDUAL : .03566 STANDARD DEVIATION : .71355

THE EVENT OCCURED ON AUG 28, 1983
AT ORIGIN TIME 10:44: 3.04 +/- .159
S. OF FLORENCE, ALABAMA
MAGNITUDE: 2.7
THE WEIGHTS ARE
WX= 1.000 WY= 1.000 WZ= 0.000 WT= 1.000
IT WAS LOCATED AT
LATITUDE 34.6478 +/- .895 KM. (34D,38.87M)
LONGITUDE 87.7764 +/- 1.268 KM. (87D,46.59M)

STATION	PHASE	HR	MIN	SEC	+OR-SEC	DIST	AZ	OBS-THE	THEOR.	DT
OCA	PLG	10	44	24.20	.10	123.02	91.8	.423	38663.78	.1
OCA	SLG	10	44	39.00	.10	123.02	91.8	.200	38678.80	.2
TDA	PLG	10	44	36.70	.10	202.08	127.0	-.146	38676.85	.1
TDA	SLG	10	45	1.50	.10	202.08	127.0	.491	38701.01	.2
TVG	PLG	10	44	40.00	.10	228.80	97.5	-1.262	38681.26	.1
TVG	SLG	10	45	7.90	.10	228.80	97.5	-.613	38708.51	.2
BKA	PLG	10	44	22.90	.10	113.83	189.0	.642	38662.26	-.0
BKA	SLG	10	44	36.10	.10	113.83	189.0	-.118	38676.22	-.0
MLA	PLG	10	44	39.50	.10	215.53	177.9	.431	38679.07	.0
DCT	PLG	10	44	54.90	.50	311.05	81.6	.043	38694.86	.1
PWL	PLG	10	44	11.70	.10	45.30	324.5	.768	38650.93	-.0
PWL	SLG	10	44	17.00	.10	45.30	324.5	.030	38656.97	-.1
EBZ	PLG	10	44	29.40	.10	154.37	290.9	.441	38668.96	-.1
PGM	SLG	10	45	3.80	.10	215.17	264.6	-.886	38704.69	-.2
PGM	PLG	10	44	38.60	.10	215.17	264.6	-.410	38679.01	-.1

ERROR ELLIPSE IS AS FOLLOWS:
SEMIMINOR AXIS LENGTH = .9108 KM.
SEMIMAJOR AXIS LENGTH = 1.4078 KM.
AZIMUTH OF MAJOR AXIS = 72.4048 DEG.
AREA OF ELLIPSE = 4.0282 SQ.KM.
ECCENTRICITY = .7625

MEAN RESIDUAL : .00232 STANDARD DEVIATION : .58544

GEORGIA INSTITUTE OF TECHNOLOGY

QUARTERLY EARTHQUAKE BULLETIN

1 September 1983 - 31 December 1983

By

Leland Timothy Long, Anton M. Dainty, Karl-Heinz Zelt,

Anthony P. Johnson, Jeih-San Liow, Robert M. Duckworth,

An Tie, Russell L. Propes, and Cesar A. Medina

School of Geophysical Sciences

Earth Sciences Division

Supported by:

Alabama Geological Survey
(through contract with U.S. Nuclear Regulatory Commission)

Georgia Power Company

U.S. Army Corps of Engineers
(Savannah District)

U.S. Geological Survey
(Contract No. 14-08-0001-21241)

Tennessee Valley Authority

U.S. Army Corps of Engineers
(Mobile District)

QUARTERLY EARTHQUAKE BULLETIN

1 September 1983 - 31 December 1983

The information presented in this bulletin includes the origin times, magnitudes, hypocentral coordinates and their precision, and the arrival times of selected phases for local earthquakes recorded by seismic stations maintained by Georgia Tech, School of Geophysical Sciences.

The network consists of 23 seismic stations located in Alabama, southeast Tennessee, Georgia, and South Carolina monitored by the School of Geophysical Sciences at Georgia Tech. Additional seismogram readings were obtained from stations operated by the Tennessee Valley Authority and the Tennessee Earthquake Information Center. The coordinates of the stations used in locating the events are given in Table 1. A map of the seismic stations maintained by Georgia Tech is given in Figure 1. Bollinger and Mathena (1983) describe the instrumentation of the seismic network and magnitude threshold.

The events are located using a computer program with techniques similar to those used in HYPO71 but is more flexible in assigning weights and utilizing phases.

Magnitudes are defined by their duration according to the equation:

$$m_b(Lg)_{Dur} = -1.7 + 2.21 \log_{10} T \ ,$$

where T is the mean signal duration in seconds (Chaplin, Taylor, and Toksöz, 1980). A map showing the epicenters can be seen in Figure 2 and is followed by data sheets containing information and individual events that occurred during the quarter.

References

Bollinger, G. A., and E. Mathena (1983). Seismicity of the southeastern United States, Southeastern U.S. Network Bulletin, 11, May 1983.

Chaplin, M. P., S. R. Taylor, and M. N. Toksöz (1980). A coda-length magnitude scale for New England, Earthquake Notes, 51, No. 4, 15-22.

Table 1. Coodinates of stations used in locating the events in this report.

Station	Latitude	Longitude	Elevation (km)
BBG	34.8740	84.3375	.2720
BHT	35.8470	84.9450	.8260
BKA	33.6339	87.9690	.1219
CBT	35.5394	84.4206	.3566
DCT	35.0542	84.4194	.5075
ETT	35.3260	84.4550	.5880
HGA	34.2602	85.8464	.3840
HPK	35.9260	83.8790	.3048
HVA	34.0264	86.7692	.1951
IVA	34.2721	82.7460	.1676
LDV	34.1479	82.6833	.1615
MLA	32.7055	87.6938	.0549
OCA	34.6138	86.4352	.2499
ORT	35.9235	84.3118	.2620
RCG	34.9750	85.3480	.4680
RCT	35.3453	84.6614	.2652
RHT	35.0781	84.8825	.2987
RMG	34.3359	85.3160	.3368
TDA	33.5417	86.0247	.1814
TKL	35.6581	83.7742	.3500
TSA	33.2561	87.0675	.1798
TVG	34.3771	85.3023	.3231

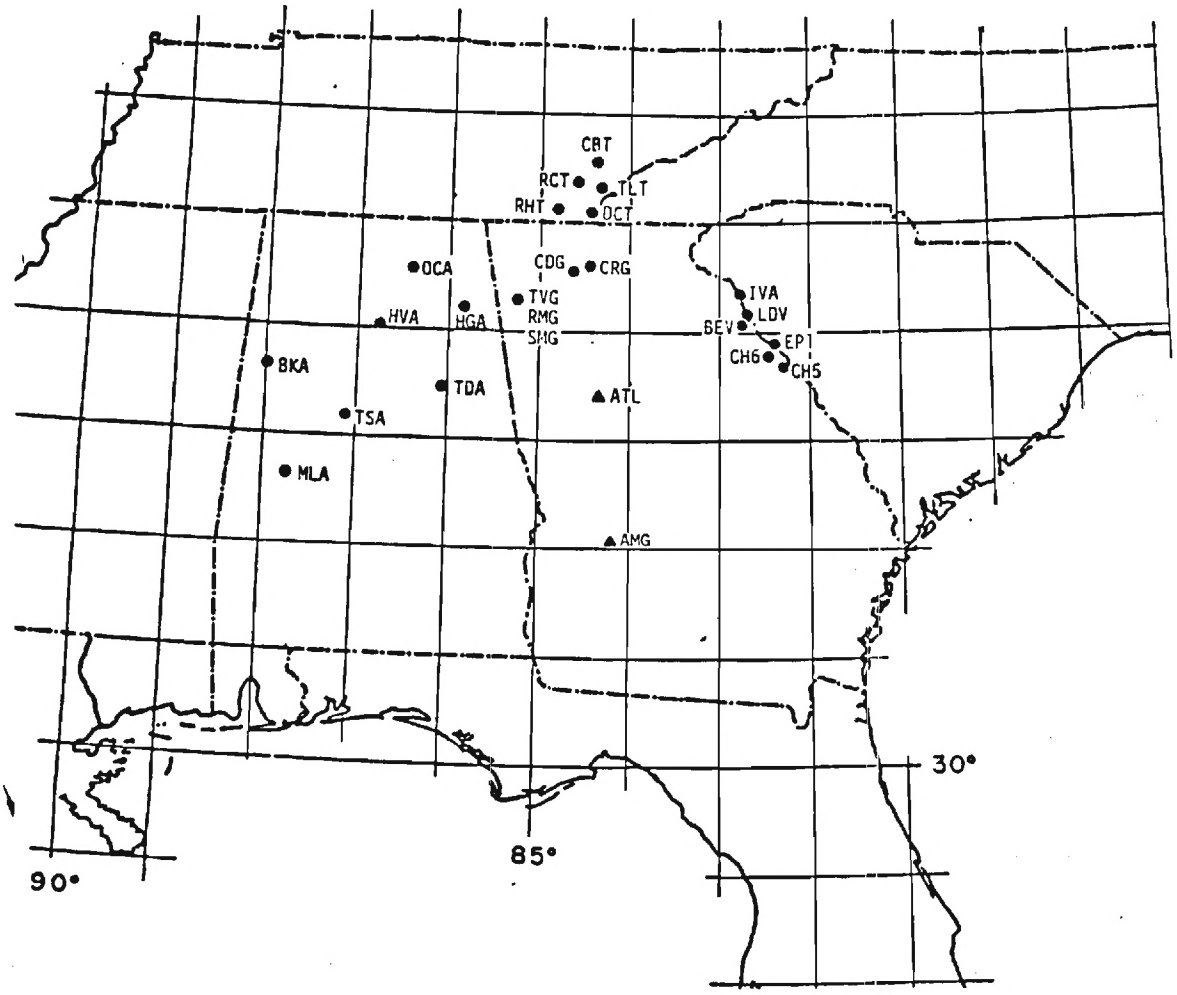

Figure 1. Seismic stations maintained by Georgia Tech as of December 1983.

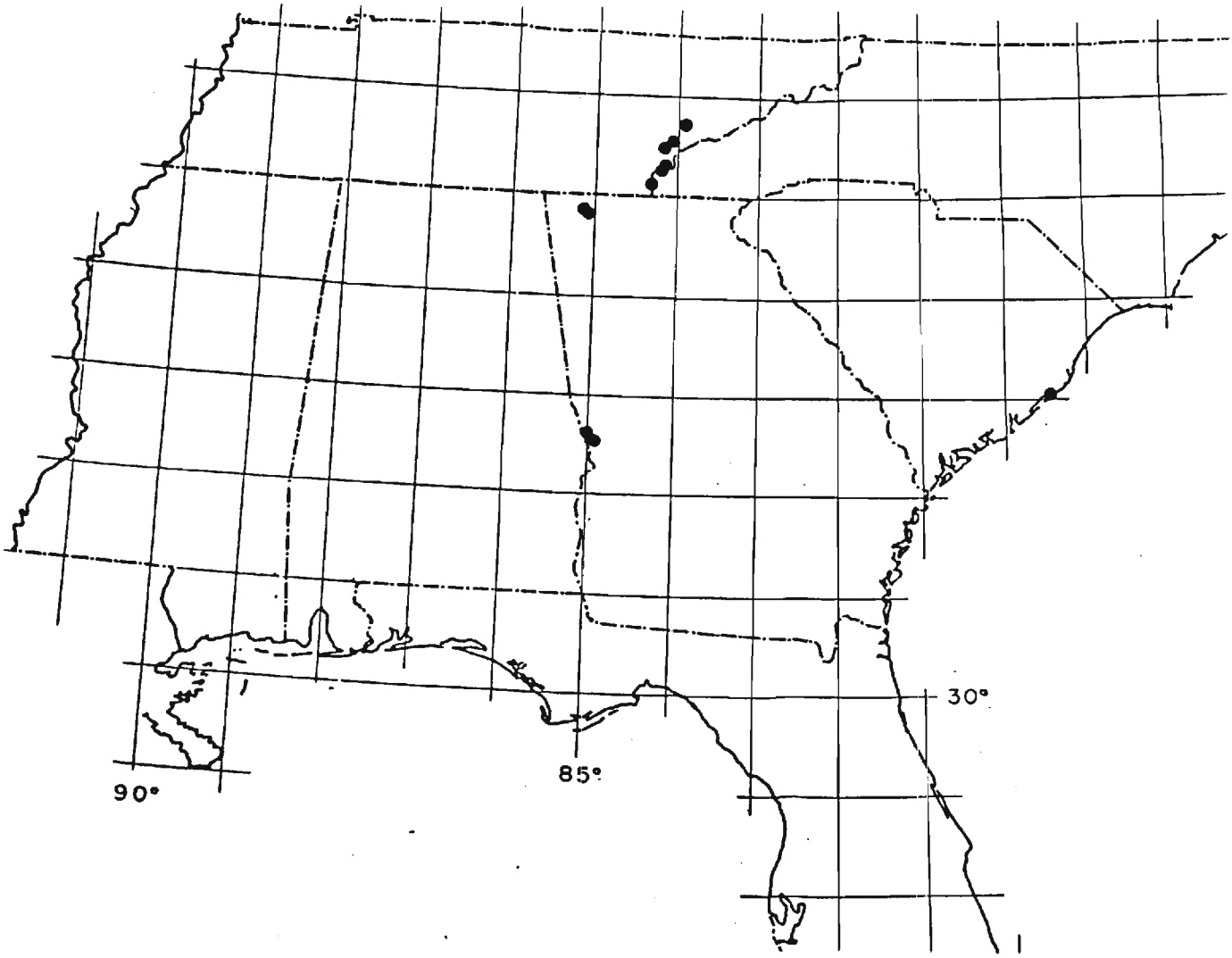

Figure 2. Epicenters from September 1, 1983 to December 31, 1983

THE EVENT OCCURED ON OCT 3, 1983
AT ORIGIN TIME 2:51:34.28 +/-   .488
LAFAYETTE, GA
MAGNITUDE: 1
THE WEIGHTS ARE
WX= 1.000 WY= 1.000 WZ= 0.000 WT= 1.000
IT WAS LOCATED AT
LATITUDE   34.8529 +/-   2.723 KM. (34D,51.18M)
LONGITUDE 85.0671 +/-   2.936 KM. (85D, 4.03M)
DEPTH   0.00   +/-   0.000 KM.

STATION	PHASE	HR	MIN	SEC	+OR-SEC	DIST	AZ	OBS-THE	THEOR.
TVG	PLG	2	51	44.20	.10	56.99	202.3	.101	10304.10
TVG	SLG	2	51	50.40	.10	56.99	202.3	-1.088	10311.49
RCG	PLG	2	51	40.52	.10	29.04	297.8	1.042	10299.48
RCG	SLG	2	51	44.55	.10	29.04	297.8	.915	10303.64
ETT	PLG	2	51	48.12	.10	76.73	46.7	.759	10307.36
ETT	SLG	2	51	58.01	.10	76.73	46.7	.978	10317.03
BHT	SLG	2	52	3.52	.10	110.83	5.7	-3.092	10326.61
BBG	SLG	2	52	7.40	.10	114.90	88.8	-.353	10327.75
TKL	SLG	2	52	17.84	.10	148.18	52.7	.737	10337.10

DIAGONAL ELEMENTS

.6314	.6808	.1131

COVARIANCE MATRIX:

3.986	1.273	-.053
1.273	4.635	.244
-.053	.244	.128

ERROR ELLIPSE IS AS FOLLOWS:
SEMIMINOR AXIS LENGTH =   2.7258 KM.
SEMIMAJOR AXIS LENGTH =   3.7344 KM.
AZIMUTH OF MAJOR AXIS =   127.8561 DEG.
AREA OF ELLIPSE   =   31.9782 SQ.KM.
ECCENTRICITY   =   .6835

THE EVENT OCCURED ON OCT 8, 1983
AT ORIGIN TIME 4:26:11.57 +/-   .455
TELLICO PLAIN, TN
MAGNITUDE: 1.7
THE WEIGHTS ARE
WX= 1.000 WY= 1.000 WZ= 0.000 WT= 1.000
IT WAS LOCATED AT
LATITUDE   35.2873 +/-   2.310 KM. (35D,17.24M)
LONGITUDE 84.1576 +/-   2.358 KM. (84D, 9.46M)
DEPTH   0.00   +/-   0.000 KM.

STATION	PHASE	HR	MIN	SEC	+OR-SEC	DIST	AZ	OBS-THE	THEOR.
DCT	PLG	4	26	18.20	.10	35.16	222.7	.419	15977.78
DCT	SLG	4	26	22.50	.10	35.16	222.7	-.145	15982.65
CBT	PLG	4	26	17.70	.10	36.80	319.5	-.352	15978.05
CBT	SLG	4	26	21.80	.10	36.80	319.5	-1.307	15983.11
ETT	PLG	4	26	16.63	.10	27.39	279.0	.133	15976.50
ETT	SLG	4	26	19.81	.10	27.39	279.0	-.654	15980.46
TKL	PLG	4	26	21.12	.10	53.93	40.2	.237	15980.88
TKL	SLG	4	26	27.80	.10	53.93	40.2	-.117	15987.92
BHT	PLG	4	26	27.16	.10	94.79	311.1	-.477	15987.64
BHT	SLG	4	26	41.66	.10	94.79	311.1	2.264	15999.40

DIAGONAL ELEMENTS
.7798 .7960 .1535

COVARIANCE MATRIX:

6.081	2.085	.806
2.085	6.336	.677
.806	.677	.236

ERROR ELLIPSE IS AS FOLLOWS:
SEMIMINOR AXIS LENGTH = 2.1557 KM.
SEMIMAJOR AXIS LENGTH = 3.0594 KM.
AZIMUTH OF MAJOR AXIS = 133.2498 DEG.
AREA OF ELLIPSE = 20.7193 SQ.KM.
ECCENTRICITY = .7096

THE EVENT OCCURED ON OCT 8, 1983
AT ORIGIN TIME 6:21:34.52 +/- .196
TELLICO PLAIN, TN
MAGNITUDE: 1.9
THE WEIGHTS ARE
WX= 1.000 WY= 1.000 WZ= 0.000 WT= 1.000
IT WAS LOCATED AT
LATITUDE 35.2241 +/- 1.221 KM. (35D,13.44M)
LONGITUDE 84.1800 +/- 1.357 KM. (84D,10.80M)
DEPTH 0.00 +/- 0.000 KM.

STATION	PHASE	HR	MIN	SEC	+OR-SEC	DIST	AZ	OBS-THE	THEOR.
CBT	PLG	6	21	42.00	.10	41.27	328.1	.262	22901.74
CBT	SLG	6	21	46.00	.10	41.27	328.1	-1.310	22907.31
ETT	PLG	6	21	39.73	.10	27.47	294.3	.273	22899.46
ETT	SLG	6	21	43.31	.10	27.47	294.3	-.122	22903.43
BBG	PLG	6	21	43.32	.10	51.34	139.0	-.083	22903.40
BBG	SLG	6	21	49.89	.10	51.34	139.0	-.249	22910.14
TKL	PLG	6	21	45.00	.10	60.69	37.4	.052	22904.95
TKL	SLG	6	21	52.99	.10	60.69	37.4	.226	22912.76
BHT	PLG	6	21	51.60	.10	98.11	315.0	.467	22911.13
BHT	SLG	6	22	3.76	.10	98.11	315.0	.485	22923.28

DIAGONAL ELEMENTS
.7403 .8227 .1189

COVARIANCE MATRIX:

5.480	-2.997	-.050
-2.997	6.769	.485
-.050	.485	.141

ERROR ELLIPSE IS AS FOLLOWS:
SEMIMINOR AXIS LENGTH = 1.0345 KM.
SEMIMAJOR AXIS LENGTH = 1.7931 KM.
AZIMUTH OF MAJOR AXIS = 51.0680 DEG.
AREA OF ELLIPSE = 5.8276 SQ.KM.
ECCENTRICITY = .8168

THE EVENT OCCURED ON OCT 8, 1983
AT ORIGIN TIME 17: 9:34.13 +/- .094
TENNESSEE
MAGNITUDE: 2.5
THE WEIGHTS ARE
WX= 1.000 WY= 1.000 WZ= 0.000 WT= 1.000
IT WAS LOCATED AT
LATITUDE 35.7207 +/- .537 KM. (35D,43.24M)
LONGITUDE 83.9762 +/- .617 KM. (83D,58.57M)
DEPTH 0.00 +/- 0.000 KM.

STATION	PHASE	HR	MIN	SEC	+OR-SEC	DIST	AZ	OBS-THE	THEOR.
CBT	PLG	17	9	42.00	.10	44.96	243.5	.041	61781.96
CBT	SLG	17	9	48.50	.10	44.96	243.5	.543	61787.96
ETT	PLG	17	9	44.32	.10	61.60	224.8	-.389	61784.71
ETT	SLG	17	9	52.25	.10	61.60	224.8	-.380	61792.63
TKL	PLG	17	9	37.78	.10	19.55	110.8	.020	61777.76
TKL	SLG	17	9	41.09	.10	19.55	110.8	.270	61780.82
HPK	PLG	17	9	38.40	.10	24.41	21.1	-.163	61778.56
HPK	SLG	17	9	42.10	.10	24.41	21.1	-.085	61782.18
ORT	PLG	17	9	40.76	.10	37.79	306.6	-.014	61780.77
ORT	SLG	17	9	46.10	.10	37.79	306.6	.157	61785.94

DIAGONAL ELEMENTS

.5989	.6880	.1043

COVARIANCE MATRIX:

3.586	.748	.177
.748	4.734	.040
.177	.040	.109

ERROR ELLIPSE IS AS FOLLOWS:
SEMIMINOR AXIS LENGTH = .5769 KM.
SEMIMAJOR AXIS LENGTH = .7265 KM.
AZIMUTH OF MAJOR AXIS = 116.2482 DEG.
AREA OF ELLIPSE = 1.3168 SQ.KM.
ECCENTRICITY = .6078

THE EVENT OCCURED ON OCT 13, 1983
AT ORIGIN TIME 10:56:16.36 +/- .212
TRENTON, GA
MAGNITUDE: 2.1
THE WEIGHTS ARE
WX= 1.000 WY= 1.000 WZ= 0.000 WT= 1.000
IT WAS LOCATED AT
LATITUDE 34.8708 +/- 3.954 KM. (34D,52.25M)
LONGITUDE 85.1235 +/- 2.371 KM. (85D, 7.41M)
DEPTH 0.00 +/- 0.000 KM.

STATION	PHASE	HR	MIN	SEC	+OR-SEC	DIST	AZ	OBS-THE	THEOR.
TVG	PLG	10	56	26.30	.10	57.15	196.7	.097	39386.20
TVG	SLG	10	56	33.50	.10	57.15	196.7	-.110	39393.61
RMG	PLG	10	56	27.00	.10	61.89	196.6	.014	39386.99
RMG	SLG	10	56	34.90	.10	61.89	196.6	-.041	39394.94
TDA	PLG	10	56	44.10	.10	168.87	209.6	-.569	39404.67
TDA	SLG	10	57	5.50	.10	168.87	209.6	.507	39424.99
CBT	PLG	10	56	33.00	.10	98.13	40.7	.023	39392.98
CBT	SLG	10	56	45.20	.10	98.13	40.7	.078	39405.12

DIAGONAL ELEMENTS
4.2303 2.5368 .2268

COVARIANCE MATRIX:

178.955	103.686	-7.737
103.686	64.353	-4.968
-7.737	-4.968	.515

ERROR ELLIPSE IS AS FOLLOWS:
SEMIMINOR AXIS LENGTH = .6244 KM.
SEMIMAJOR AXIS LENGTH = 5.4192 KM.
AZIMUTH OF MAJOR AXIS = 149.4633 DEG.
AREA OF ELLIPSE = 10.6301 SQ.KM.
ECCENTRICITY = .9933

THE EVENT OCCURED ON OCT 16, 1983
AT ORIGIN TIME 22: 2:48.49 +/- .815
KINGSTON, TN
MAGNITUDE: 2.7
THE WEIGHTS ARE
WX= 1.000 WY= 1.000 WZ= 0.000 WT= 1.000
IT WAS LOCATED AT
LATITUDE 35.5565 +/- 3.744 KM. (35D,33.39M)
LONGITUDE 84.0593 +/- 2.404 KM. (84D, 3.56M)
DEPTH 0.00 +/- 0.000 KM.

STATION	PHASE	HR	MIN	SEC	+OR-SEC	DIST	AZ	OBS-THE	THEOR.
RMG	PLG	22	3	18.10	.10	176.95	220.5	-.039	79398.14
RMG	SLG	22	3	39.00	.10	176.95	220.5	-.397	79419.40
TVG	PLG	22	3	17.50	.10	172.67	221.2	.069	79397.43
TVG	SLG	22	3	38.80	.10	172.67	221.2	.607	79418.19
CBT	PLG	22	2	54.30	.10	32.81	266.7	-.015	79374.32
CBT	SLG	22	2	58.90	.10	32.81	266.7	-.009	79378.91
TDA	SLG	22	4	8.90	.50	285.81	219.2	-1.075	79449.97

DIAGONAL ELEMENTS
2.3313 1.6132 .5114

COVARIANCE MATRIX:

53.177	-9.630	10.381
-9.630	21.922	-4.546
10.381	-4.546	2.522

ERROR ELLIPSE IS AS FOLLOWS:
SEMIMINOR AXIS LENGTH = 2.8451 KM.
SEMIMAJOR AXIS LENGTH = 4.8556 KM.
AZIMUTH OF MAJOR AXIS = 15.8209 DEG.
AREA OF ELLIPSE = 43.3999 SQ.KM.
ECCENTRICITY = .8104

THE EVENT OCCURED ON OCT 17, 1983
AT ORIGIN TIME 7:45:20.38 +/- .319
TELLICO PLAINS, TN
MAGNITUDE: 3.1
THE WEIGHTS ARE
WX= 1.000 WY= 1.000 WZ= 0.000 WT= 1.000
IT WAS LOCATED AT
LATITUDE 35.5298 +/- .989 KM. (35D,31.79M)
LONGITUDE 84.1508 +/- 1.816 KM. (84D, 9.05M)
DEPTH 0.00 +/- 0.000 KM.

STATION	PHASE	HR	MIN	SEC	+OR-SEC	DIST	AZ	OBS-THE	THEOR.
RMG	PLG	7	45	48.30	.20	169.42	219.0	-.480	27948.78
RMG	SLG	7	46	9.30	.50	169.42	219.0	.134	27969.17
TVG	PLG	7	45	47.30	.10	165.08	219.6	-.763	27948.06
TVG	SLG	7	46	8.00	.10	165.08	219.6	.051	27967.95
DCT	SLG	7	45	38.70	.30	58.11	204.9	.801	27937.90
CBT	PLG	7	45	25.20	.10	24.49	272.5	.375	27924.82
CBT	SLG	7	45	28.60	.10	24.49	272.5	.144	27928.46
LDV	PLG	7	45	54.50	.50	202.99	138.6	.170	27954.33
LDV	SLG	7	46	19.00	.50	202.99	138.6	.402	27978.60
IVA	PLG	7	45	51.50	.20	188.92	137.2	-.504	27952.00
IVA	SLG	7	46	15.20	.20	188.92	137.2	.554	27974.65

DIAGONAL ELEMENTS

.9791	1.4995	.2682

COVARIANCE MATRIX:

4.220	-2.785	.608
-2.785	14.231	-2.199
.608	-2.199	.439

ERROR ELLIPSE IS AS FOLLOWS:
SEMIMINOR AXIS LENGTH = 1.0219 KM.
SEMIMAJOR AXIS LENGTH = 2.1130 KM.
AZIMUTH OF MAJOR AXIS = 75.4542 DEG.
AREA OF ELLIPSE = 6.7836 SQ.KM.
ECCENTRICITY = .8753

THE EVENT OCCURED ON NOV 6, 1983
AT ORIGIN TIME 9: 2:12.41 +/- 1.143
SUMMERVILLE, SC
MAGNITUDE: 3.2
THE WEIGHTS ARE
WX= 1.000 WY= 1.000 WZ= 0.000 WT= 1.000
IT WAS LOCATED AT
LATITUDE 33.0581 +/- 10.690 KM. (33D, 3.49M)
LONGITUDE 79.5042 +/- 13.128 KM. (79D,30.25M)
DEPTH 0.00 +/- 0.000 KM.

STATION	PHASE	HR	MIN	SEC	+OR-SEC	DIST	AZ	OBS-THE	THEOR.
IVA	PN	9	3	0.00	.10	331.35	294.3	-.334	32580.33
LDV	PN	9	2	59.00	.10	320.56	292.4	-.018	32579.02
LDV	SN	9	3	34.50	.10	320.56	292.4	1.050	32613.45
HGA	PN	9	3	33.20	.10	607.14	282.9	-.792	32613.99
TDA	PN	9	3	35.00	.10	611.32	275.1	.522	32614.48
TSA	PN	9	3	46.00	.10	706.68	271.8	-.108	32626.11
RHT	SN	9	4	20.90	.10	550.00	294.5	-1.041	32661.94
BBG	PN	9	3	15.50	.10	449.83	297.1	.720	32594.78

DIAGONAL ELEMENTS
4.6322 5.6884 .4953

COVARIANCE MATRIX:

214.572	-186.655	20.752
-186.655	323.578	-10.857
20.752	-10.857	2.453

ERROR ELLIPSE IS AS FOLLOWS:
SEMIMINOR AXIS LENGTH = 7.4594 KM.
SEMIMAJOR AXIS LENGTH = 18.5907 KM.
AZIMUTH OF MAJOR AXIS = 53.1389 DEG.
AREA OF ELLIPSE = 435.6618 SQ.KM.
ECCENTRICITY = .9160

THE EVENT OCCURED ON DEC 30, 1983
AT ORIGIN TIME 2: 5:18.35 +/-   .116
N OF DUCKTOWN, TN
MAGNITUDE: 3.2
THE WEIGHTS ARE
WX= 1.000 WY= 1.000 WZ= 0.000 WT= 1.000
IT WAS LOCATED AT
LATITUDE   35.1934 +/-   1.209 KM. (35D,11.61M)
LONGITUDE 84.4165 +/-   .465 KM. (84D,24.99M)
DEPTH   0.00   +/-   0.000 KM.

STATION	PHASE	HR	MIN	SEC	+OR-SEC	DIST	AZ	OBS-THE	THEOR.
DCT	PG	2	5	21.00	.10	15.46	181.0	-.159	7521.16
DCT	S	2	5	23.30	.10	15.46	181.0	.084	7523.22
CBT	PLG	2	5	25.50	.20	38.38	359.4	.408	7525.09
CBT	SLG	2	5	30.20	.10	38.38	359.4	-.129	7530.33
RCT	SLG	2	5	27.40	.10	27.95	307.1	.000	7527.40

DIAGONAL ELEMENTS

1.7370	.6723	.1738

COVARIANCE MATRIX:

28.245	-3.325	1.259
-3.325	4.178	-.058
1.259	-.058	.258

ERROR ELLIPSE IS AS FOLLOWS:
SEMIMINOR AXIS LENGTH = .6334 KM.
SEMIMAJOR AXIS LENGTH = 1.7575 KM.
AZIMUTH OF MAJOR AXIS = 7.7219 DEG.
AREA OF ELLIPSE   = 3.4972 SQ.KM.
ECCENTRICITY   = .9328

THE EVENT OCCURED ON DEC 31, 1983
AT ORIGIN TIME 6:31:10.80 +/-   1.742
COLUMBUS, GA
MAGNITUDE: 3.2
THE WEIGHTS ARE
WX= 1.000 WY= 1.000 WZ= 0.000 WT= 1.000
IT WAS LOCATED AT
LATITUDE   32.6101 +/-   7.195 KM. (32D,36.61M)
LONGITUDE 85.0431 +/-   5.351 KM. (85D, 2.58M)
DEPTH   0.00   +/-   0.000 KM.

STATION	PHASE	HR	MIN	SEC	+OR-SEC	DIST	AZ	OBS-THE	THEOR.
HGA	PLG	6	31	44.70	.10	197.91	338.0	.787	23503.91
HGA	SLG	6	32	8.60	.10	197.91	338.0	1.007	23527.59
OCA	SLG	6	32	23.90	.10	257.78	330.1	-.509	23544.41
HVA	SLG	6	32	15.00	.10	225.65	314.6	-.384	23535.38
BKA	PLG	6	31	57.90	.10	297.18	292.7	-2.420	23520.32
BKA	SLG	6	32	35.00	.10	297.18	292.7	-.476	23555.48
MLA	PLG	6	31	53.00	.10	249.01	272.4	.642	23512.36
MLA	SLG	6	32	23.30	.10	249.01	272.4	1.354	23541.95

DIAGONAL ELEMENTS
    1.8692   1.3902   .4527

COVARIANCE MATRIX:

34.940	12.785	7.655
12.785	19.328	4.704
7.655	4.704	2.049

ERROR ELLIPSE IS AS FOLLOWS:
SEMIMINOR AXIS LENGTH =   5.0211 KM.
SEMIMAJOR AXIS LENGTH =   9.3462 KM.
AZIMUTH OF MAJOR AXIS =   150.7043 DEG.
AREA OF ELLIPSE   =   147.4293 SQ.KM.
ECCENTRICITY   =   .8434

THE EVENT OCCURED ON DEC 31, 1983
AT ORIGIN TIME 17:17:23.62 +/- 1.303
COLUMBUS, GA
MAGNITUDE: 3.2
THE WEIGHTS ARE
WX= 1.000 WY= 1.000 WZ= 0.000 WT= 1.000
IT WAS LOCATED AT
LATITUDE 32.5389 +/- 3.880 KM. (32D,32.34M)
LONGITUDE 84.9005 +/- 5.800 KM. (84D,54.03M)
DEPTH 0.00 +/- 0.000 KM.

STATION	PHASE	HR	MIN	SEC	+OR-SEC	DIST	AZ	OBS-THE	THEOR.
DCT	PLG	17	18	10.40	.10	282.58	8.9	-.330	62290.73
DCT	SLG	17	18	43.20	.10	282.58	8.9	-.999	62324.20
BKA	PLG	17	18	15.90	.10	312.77	293.1	.179	62295.72
BKA	SLG	17	18	51.90	.10	312.77	293.1	-.780	62332.68
HGA	PLG	17	18	0.00	.10	210.54	335.5	1.177	62278.82
HGA	SLG	17	18	25.30	.10	210.54	335.5	1.336	62303.96
HVA	SLG	17	18	31.90	.10	240.87	313.7	-.584	62312.48

DIAGONAL ELEMENTS

1.3107	1.9590	.4403

COVARIANCE MATRIX:

17.180	12.695	3.994
12.695	38.378	7.966
3.994	7.966	1.938

ERROR ELLIPSE IS AS FOLLOWS:
SEMIMINOR AXIS LENGTH = 3.8443 KM.
SEMIMAJOR AXIS LENGTH = 7.6329 KM.
AZIMUTH OF MAJOR AXIS = 115.0704 DEG.
AREA OF ELLIPSE = 92.1835 SQ.KM.
ECCENTRICITY = .8639

Seismic Monitoring of the Richard B. Russell Dam Impoundment

3-9900-01268

L. T. Long
School of Geophysical Sciences
Georgia Institute of Technology
Atlanta, Georgia 30332
(404) 894-2860

Investigations

1. The first objective of the project is to develop three instruments to site in the Richard B. Russell Lake area. This will augment an existing four-station net to seven stations should reservoir induced seismicity be detected.

2. The second objective is to obtain a set of unique data which can be used to study, in detail and with precision, a small sub-area of induced seismicity. The data set will allow precision determination of depth, focal mechanism, and spectra for small shallow events.

3. The third objective has been to investigate the relation between high-frequency spectral slope and depth of focus. The objective of this investigation is to relate the spectral properties of reservoir induced earthquakes to the state of stress and perhaps be able to estimate the largest event that might be induced in a particular reservoir area.

Results

1. We have three stations on hold for possible installation in the Richard B. Russell area should induced seismicity be detected.

2. The components for six systems have been purchased, and we are in the process of assembling the components.

3. The frequency content of earthquakes recorded in the Monticello, South Carolina, and the Mammoth Lakes, California, areas have been examined as a function of depth of focus. For each event we determined the depth-of-focus and slope of the displacement spectra above the corner frequency. In the Monticello, South Carolina, area the range of depths was too narrow to determine a relationship with spectral slope. However, in the Mammoth Lakes area a relation between slope above the corner frequency and depth-of-focus was observed. Spectra which decay at a rate of ω^{-3} or higher were predominantly observed for shallow events. Events with a deeper focus typically had a displacement spectra decay rate less than ω^{-3}. The relation is shown in Figure 1.

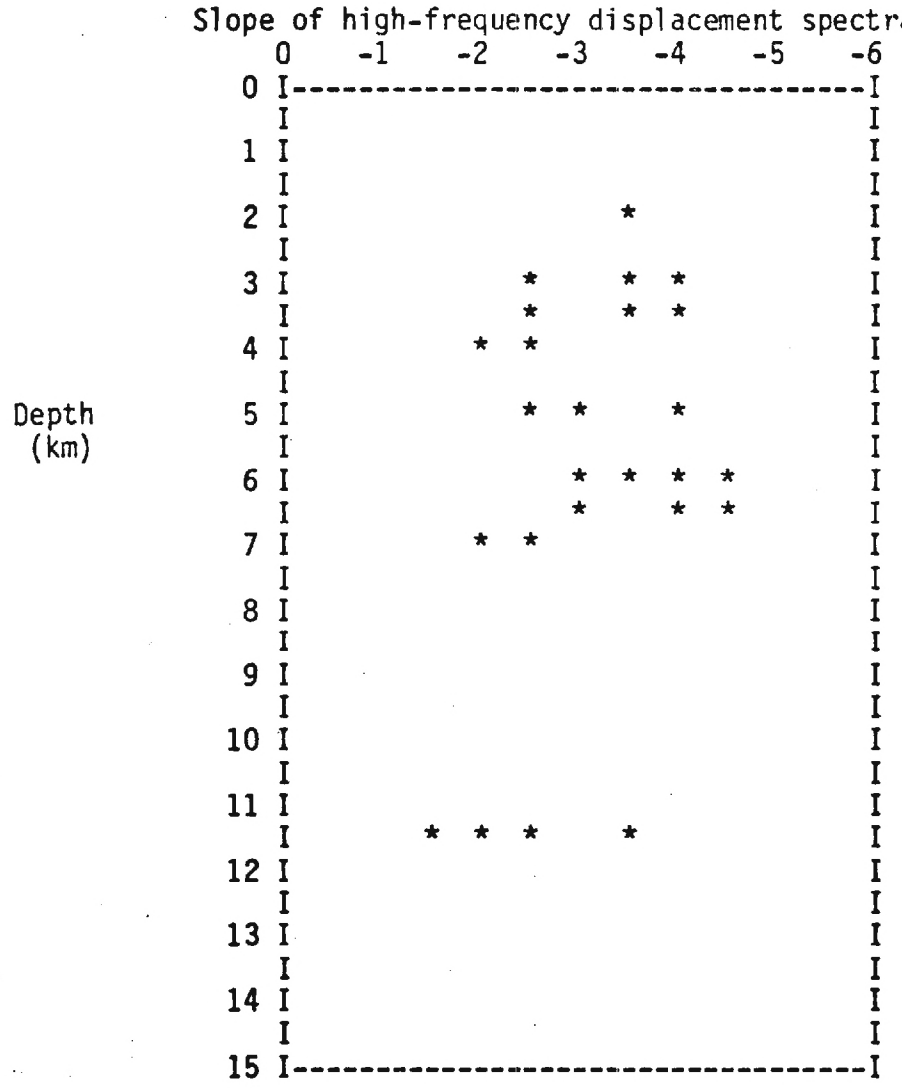

Figure 1. Relation between depth of focus and spectral slope above the corner frequency. Depth of focus is computed indirectly from the direction of propagation.

Reports

Long, L. T., and Wilson, Jeffrey, 1983, Investigation of high-frequency spectral slope versus depth (Abstract): Earthquake Notes, v. 54, no. 1, p. 32.

Seismic Monitoring of the Richard B. Russell Dam Impoundment

14-08-0001-21241

Leland Timothy Long
School of Geophysical Sciences
Georgia Institute of Technology
Atlanta, Georgia 30332
(404) 894-2860

During the first six months of impoundment with water depths up to 30 meters, the Richard B. Russell Reservoir failed to induce observable seismicity. A lack of activity was unexpected since many neighboring reservoirs have exhibited reservoir induced seismicity. At this time, the reason for a lack of reservoir induced seismicity is unknown. However, the lack of seismicity could be explained by a delayed onset of seismicity, much like the delay in occurrence of larger events at the adjacent Clarks Hill Reservoir. Also, the geologic terrain and condition of ambient stress in the Richard B. Russell reservoir may differ substantially from adjacent areas.

Objective: The proposed work on this project had two objectives. The first was to assist in monitoring induced seismicity at the Richard B. Russell reservoir and thus permit a direct comparison with patterns of induced seismicity elsewhere. The observed patterns could also permit direct comparison with the surface geology. The second objective was to use high-frequency seismic recording systems to obtain detailed near-source data which would permit precision location of shallow reservoir induced earthquakes. The precision anticipated would be sufficient to document the progression of seismic activity as a function of depth and time. Hence, it was hoped that the detailed microseismicity would allow tracing of fluid movement to depth, and documentation of the growth in areal extent and magnitude of earthquakes in active zones.

Results: The monitoring of the Richard B. Russell area was achieved through a permanent four-station net. Three of these stations were converted to RF telemetry, and the fourth is located at the central RF receiving site. The mixed signals are transmitted via telephone to Georgia Tech for recording. The four-station net in the Richard B. Russell Reservoir area is augmented by three stations in the Clarks Hill Reservoir area.

The seismic monitoring net has allowed a complete documentation and location of all active quarries and most road construction sites requiring blasting. Travel times from the quarries indicate a P-wave velocity of 6.05 km/s (see Figure 1) measured in a northwest direction. Similarly, a P-wave velocity of 6.05 km/s was obtained from refraction data striking northeast. The velocity measurements in orthogonal directions show no evidence for anisotropy in the shallow crust.

The seismic net has detected no natural or induced activity in the area of the Richard B. Russell Reservoir (as of September 1984). Some

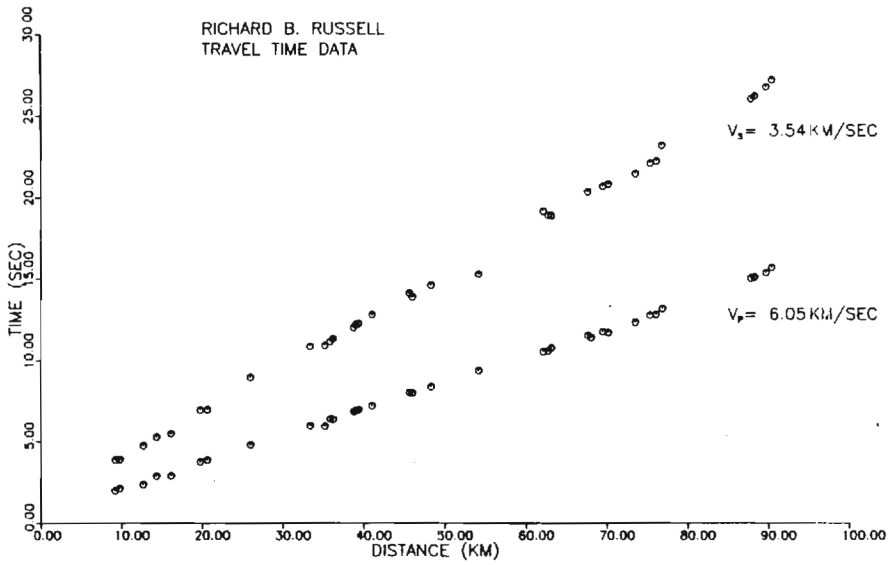

Figure 1. Travel times from blasts in the vicinity of the Richard B. Russell reservoir.

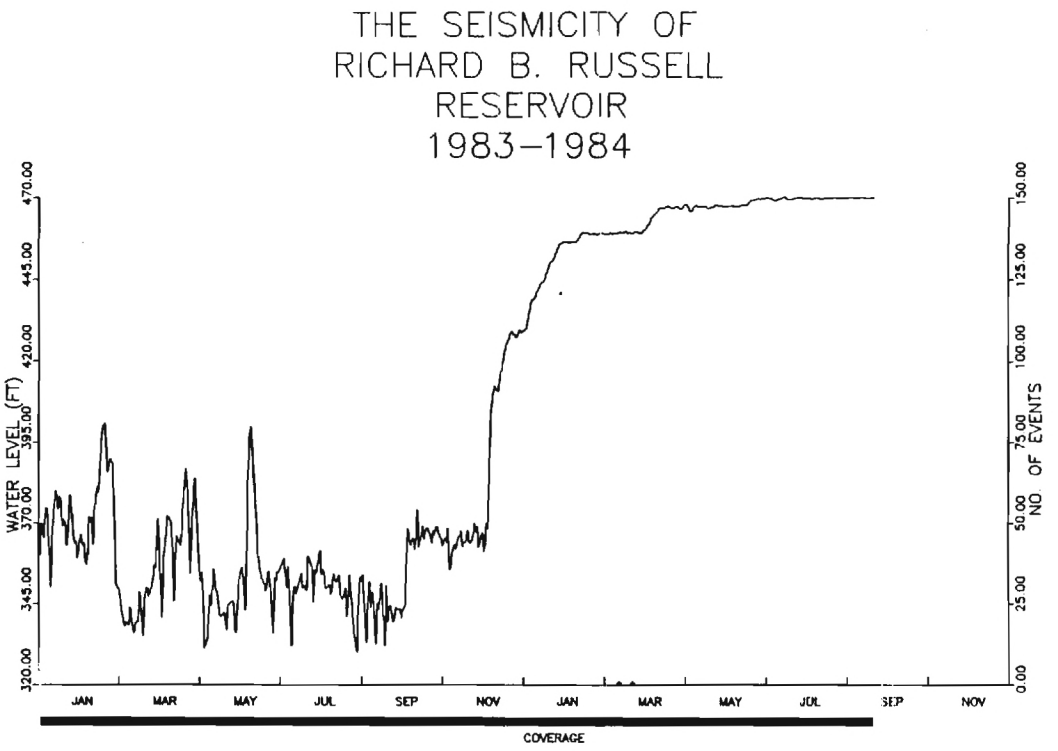

Figure 2. Water level history of filling of the Richard B. Russell Reservoir. Activity (none) and station coverage shown at bottom of the figure.

activity has continued in the McCormick area of the Clarks Hill Reservoir, but this area is outside the hydrologic influence of the Richard B. Russell reservoir. Figure 2 shows the water level versus time and the record of (non)activity.

Two explanations are offered for the present lack of seismicity. First, induced seismicity in this area may take longer to develop and the seismic data are documenting a delay in activity. The delay may relate to the rapid filling, which was accompanied by a disturbance of the soil and perhaps a sealing of joints and fractures by suspended clay. Thus, the downward penetration of water is limited or delayed. The time of year and perhaps water temperature may also contribute to effective permeability. Second, the geologic formations under the southern half of the Richard B. Russell Reservoir differ in average composition from formations under neighboring reservoirs. Much of the Richard B. Russell Reservoir below the Middleton-Lowndesville fault is underlain by mafic rocks which may be described as a melange. In contrast, the Clarks Hill Reservoir area is underlain by a mix of mafic volcanics and granitic intrusives. The stress release characteristics and permeability of these two types of units may differ, and this difference may be reflected in the existence of induced seismicity.

Final Technical Report

SEISMIC MONITORING OF THE RICHARD B. RUSSELL DAM IMPOUNDMENT

by

Leland Timothy Long
Principal Investigator

Sponsored by the
U. S. Geological Survey

Contract No. 14-08-0001-21241
Effective Date of Contract: December 1, 1982
Contract Expiration Date: November 31, 1983
Amount of Contract: $31,860
Government Technical Officer: Karen Ward

November 1984

GEORGIA INSTITUTE OF TECHNOLOGY
A unit of the University System of Georgia

School of Geophysical Sciences
Atlanta, Georgia 30332

PROJECT SUMMARY

During the first six months of impoundment with water depths up to 30 meters, the Richard B. Russell Reservoir failed to induce observable seismicity. A lack of activity was unexpected since many neighboring reservoirs have exhibited reservoir induced seismicity. At this time, the reason for a lack of reservoir induced seismicity is unknown. However, the lack of seismicity could be explained by a delayed onset of seismicity, much like the delay in occurrence of larger events at the adjacent Clarks Hill Reservoir. Also, the geologic terrain and condition of ambient stress in the Richard B. Russell Reservoir may differ substantially from adjacent areas.

Objective: The proposed work on this project had two objectives. The first was to assist in monitoring induced seismicity at the Richard B. Russell Reservoir and thus permit a direct comparison with patterns of induced seismicity elsewhere. The observed patterns could also permit direct comparison with the surface geology. The second objective was to use high-frequency seismic recording systems to obtain detailed near-source data which would permit precision location of shallow reservoir induced earthquakes. The precision anticipated would be sufficient to document the progression of seismic activity as a function of depth and time. Hence, it was hoped that the detailed microseismicity would allow tracing of fluid movement to depth, and documentation of the growth in areal extent and magnitude of earthquakes in active zones.

Results: The monitoring of the Richard B. Russell area was achieved through a permanent four-station net. Three of these stations were converted to RF telemetry, and the fourth is located at the central RF receiving site. The mixed signals are transmitted via telephone to Georgia Tech for recording. The four-station net in the Richard B. Russell Reservoir area is augmented by three stations in the Clarks Hill Reservoir area.

The seismic monitoring net has allowed a complete documentation and location of all active quarries and most road construction sites requiring blasting. Travel times from the quarries indicate a P-wave velocity of 6.05 km/s measured in a northwest direction. Similarly, a P-wave velocity of 6.05 km/s was obtained from refraction data striking northeast. The velocity measurements in orthogonal directions show no evidence for anisotropy in the shallow crust.

The seismic net has detected no natural or induced activity in the area of the Richard B. Russell Reservoir (as of September 1984). Some activity has continued in the McCormick area of the Clarks Hill Reservoir, but this area is outside the hydrologic influence of the Richard B. Russell Reservoir.

Two explanations are offered for the present lack of seismicity. First, induced seismicity in this area may take longer to develop and the seismic data are documenting a delay in activity. The delay may

relate to the rapid filling, which was accompanied by a disturbance of the soil and perhaps a sealing of joints and fractures by suspended clay. Thus, the downward penetration of water is limited or delayed. The time of year and perhaps water temperature may also contribute to effective permeability. Second, the geologic formations under the southern half of the Richard B. Russell Reservoir differ in average composition from formations under neighboring reservoirs. Much of the Richard B. Russell Reservoir below the Middleton-Lowndesville fault is underlain by mafic rocks which may be described as a melange. In contrast, the Clarks Hill Reservoir area is underlain by a mix of mafic volcanics and granitic intrusives. The stress release characteristics and permeability of these two types of units may differ, and this difference may be reflected in the existence of induced seismicity. Observations of induced earthquakes at other reservoirs in the Piedmont indicate a preference for granite gneiss over mafic or foliated rocks.

TABLE OF CONTENTS

LIST OF FIGURES

INDUCED SEISMICITY

Introduction

The first six months and up to 30 meters of water impounded at the Richard B. Russell Dam failed to trigger an observable sequence of earthquakes. A lack of seismic activity was unexpected since many of the recent earthquakes in the Piedmont Province have epicenters near reservoirs and have been identified as reservoir induced events. These include extensively well documented sequences of induced seismicity at Jocassee and Monticello Reservoirs (Talwani, 1979; Zoback and Hickman, 1982). In both of these reservoirs, significant seismicity followed within a few months of impoundment. In contrast, Lake Oconee, which was carefully monitored during impoundment in the spring of 1979, generated only a short sequence of magnitude less than zero events in the spring of 1980. Also, the Clarks Hill Reservoir triggered most of its activity in 1969 and the largest event in August 1974, some one to two decades after impoundment. Hence, the timing of significant induced seismicity is not uniform and the potential for siginificant reservoir induced seismicity may not be obvious in the first six months following impoundment.

A relation between reservoir induced seismicity and historical seismicity in the Georgia-South Carolina Piedmont is contradictory. Only two areas, Lake Sinclair, Georgia, and Clarks Hill Lake, Georgia, have historical seismicity and inferred reservoir induced seismicity. In contrast, both Jocassee and Monticello lack well documented evidence for historical seismicity. In the Richard B. Russell impoundment area, the historical seismicity is devoid of events. The closest events are near Due West, which is 40 km to the east, and the Clarks Hill Reservoir area near McCormick, South Carolina, which is 10 km south of the Richard B. Russell Dam.

In most respects, including water depth, surface area, and general geologic framework, the reservoirs in the Piedmont Province are similar. Water depth and historical seismicity seem to be independent of the occurrence of reservoir induced seismicity, except that reservoirs near historical seismicity have continued to demonstrate evidence of seismicity which could include induced earthquakes. Perhaps, an incomplete historical record could explain the lack of historical seismicity near those reservoirs that induced seismicity with no indication of prior seismicity. The areas of induced seismicity seem to be localized and do not necessarily occur in the deepest parts of the reservoirs. The McCormick area of the Clarks Hill Reservoir was near 15 meters of water at most, and the area of intense aftershock activity was adjacent to, not underneath, the reservoir. The non-uniform distribution of seismicity suggests that subtle variations in surface geology may control reservoir induced activity in the Piedmont Province.

The extent and location of the Richard B. Russell reservoir make it an ideal reservoir for evaluating geologic factors associated with

induced seismicity. The first objective of this study was to assist in monitoring the Richard B. Russell Reservoir before, during, and after impoundment. The time variation of seismicity and its correlation with the filling curve was to be a product of this study. This curve could be compared directly to the filling versus seismicity curve for other reservoirs. The location of the events would allow an association of the seismicity with specific geologic structures and possibly help develop an understanding of conditions conducive to reservoir induced seismicity. The second objective of this study was to carry out a detailed field investigation of a small area of induced seismicity. The study would use 10 to 20 tape recorders capable of recording seismic data in the 40 to 300 Hz range. Data at these high frequencies are capable of locating events to within about 20 meters. The density of sensors would allow reliable depths, focal mechanisms, and stress drops. The emphasis of the detailed investigation would be on the initiation process. The initiation process may not be observed in reservoirs that have been active for some time.

Filling Curve

The filling curve for the Richard B. Russell Reservoir (Figure 1) shows a rapid achievement of full capacity. The rapid filling was facilitated by unusually heavy rains at the time of filling. Because the pool for the first 10 to 15 meters was limited to the river bed, the full influence of the reservoir was not realized until the level exceeded 15 meters (400 ft elevation level). Prior to closing the gate in December a rapidly changing and irregular variation in level was observed. The extent of the pool at these times was limited to the river bed just above the dam and hence, before closing the gates in December, no significant impoundment occurred. Full pool was reached in April 1984 after clearing of bush and trees was complete. No significant variation in pool elevation is expected in the future.

SURFACE GEOLOGY

Lake Sinclair Geology

Lake Sinclair and Lake Oconee in central Georgia are underlain by rocks which have been correlated with the Carolina Slate belt in North and South Carolina, and which underlie the areas of seismicity in the Clarks Hill Reservoir and Monticello Reservoir. In the Lake Sinclair area the rocks vary from the Siloam Granite to meta-gabbro and norite. However, most of the seismic activity was associated with one unit described as a biotite granitic gneiss, feldspathic biotite amphibolite gneiss on the geologic map of Georgia (Georgia Geological Survey, 1976). The gneiss unit is generally inhomogeneous. The degree of foliation and continuity are unknown.

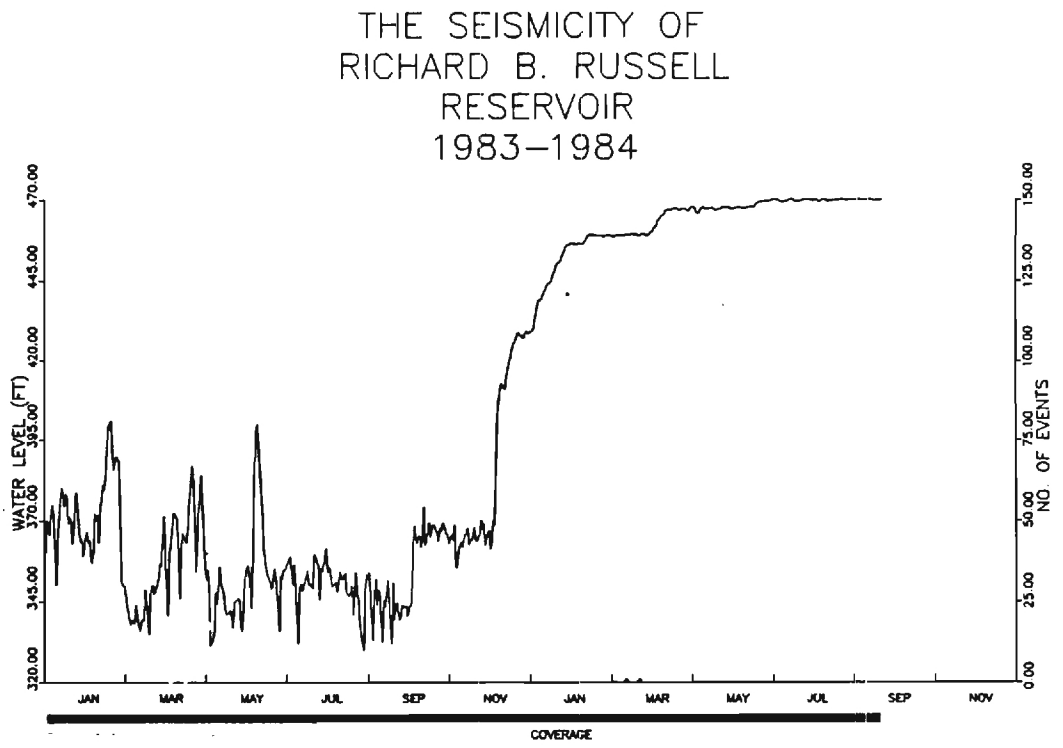

Figure 1. Water levels and seismic coverage versus time in the Richard B. Russell Reservoir area.

Monticello Geology

The area of induced seismicity of the Monticello Reservoir is almost entirely contained within the Winnsboro plutonic complex (Secor and others, 1982). The Winnsboro complex is generally unfoliated, although gneissic layering is present in some places. The Winnsboro plutonic complex also contains numerous diversely oriented small fractures and lithological inhomogeneities of maximum length of the order of 1-2 km. According to Secor and others (1982), the small fractures and lithological inhomogeneities control the induced seismicity. The lack of continuous foliation is notable and could explain the existence of significant residual stress.

Piedmont Geology

Recent studies of the geology of the Georgia Piedmont (Higgins and others, 1982) describe the country rock as a complex melange of thrust sheets stacked sequentially during a Paleozoic collision episode. The granitic intrusives were emplaced during the later (450 to 250 ma) portion of the ultimate collision of the North American craton with Africa and/or a Piedmont microplate. Hence, the exposed Piedmont today presents a complex pattern of deformed thrust sheets and granitic intrusions. The thrust sheets were originally derived from shelf-edge sediments, mid-ocean ridge sediments, and ocean floor deposits. The first thrust sheets to develop were derived from the sediments and ocean floor adjacent to the North American Craton. These are now found in the Inner Piedmont, Brevard Zone, and Blue Ridge. The last thrust sheets to develop were derived from a Precambrian or Cambrian island arc and shelf edge sediments associated with the African continent or Piedmont microplate. These are now found southeast of the Towaliga or Middleton-Lowndesville fault and make up most of the Charlotte and Carolina Slate belt. The trace of the Middleton-Lowndesville fault strikes east-northeast through the central portion of the Richard B. Russell impoundment.

North of this fault, the metasediments and granites of the Inner Piedmont dominate. South of this fault, island arc sediments and mafic rocks dominate. Hence, the area of greatest water depths and surface area in the Richard B. Russell Reservoir is dominated by the more mafic rock units and not by the granites and gneisses which were associated with the Lake Sinclair, Clarks Hill, and Monticello induced seismic activity.

The association of induced seismic activity and geology which is developing from continued monitoring and geologic mapping is tenuous at this time. The primary deficiency is in availability of geologic maps showing those qualities of rock units that are significant for induced seismicity, such as foliation, schistosity, jointing, and weathering characteristics. Most geologic maps are based on structural and compositional distributions. The comparisons noted above indicate a preference of induced seismicity to occur in granite gneisses. This term is probably applied to units in which the foliation is poorly developed or

discontinuous, as best described for the Winnsboro gneissic complex at the Monticello reservoir. None of the observed sequences of induced seismicity appears to be located in predominantly mafic rock units or in the larger homogeneous granites.

SEISMIC MONITORING

Description of the RBR Seismic Net

The Richard B. Russell seismic net consists of four vertical-component short-period seismic systems. The four stations (see Figure 2) form an elongated array striking north-northwest. The four sites are furnished and maintained by the Savannah District, Corps of Engineers. Maintenance of the microearthquake monitoring system is provided through the mutual support of Georgia Tech and the Savannah District, Corps of Engineers. Georgia Tech and the Savannah District, Corps of Engineers also agree to the mutual use of the microearthquake monitoring system in the area between Hartwell and Clarks Hill Reservoirs. Use of the data is confined to non-profit research.

The northernmost station is IVA because it is 8 km west-southwest of Iva, South Carolina. IVA is within 1.0 km of the Savannah River and 13 km southeast of Hartwell Lake. Station LDV is 8 km south-southwest of Lowndesville, South Carolina, and 15 km northwest of the Richard B. Russell Dam site, at the headwaters of Clarks Hill Reservoir. Station BEV is near the former town of Beverly, Georgia, and 14 km west-northwest of the dam site. Station CHF is located adjacent to the dam on the South Carolina side of the Savannah River.

Data from stations BEV, LDV, and IVA are transmitted by radio telemetry to the Corps of Engineers microwave tower at the Richard B. Russell Dam site. At the microwave tower, they are mixed with station CHF and the mixed signal is transmitted to Georgia Tech by a combination of microwave and telephone telemetry. At Georgia Tech, the signals are recorded on helical ink recorders and events recorded on digital or analog tape recording systems.

Proposed New Station Locations

Four new sites were chosen to complement the Richard B. Russell seismic net and to increase station density in the reservoir impoundment area. These sites were originally constrained by topography. However, the ease of RF telemetry facilitated by the central receiving site on the microwave tower has made many more sites accessible. Hence, it was decided to use the location of induced seismicity as a guide for placing any additional stations. Because of the sparsity of induced seismicity, no additional sites for new stations have been determined.

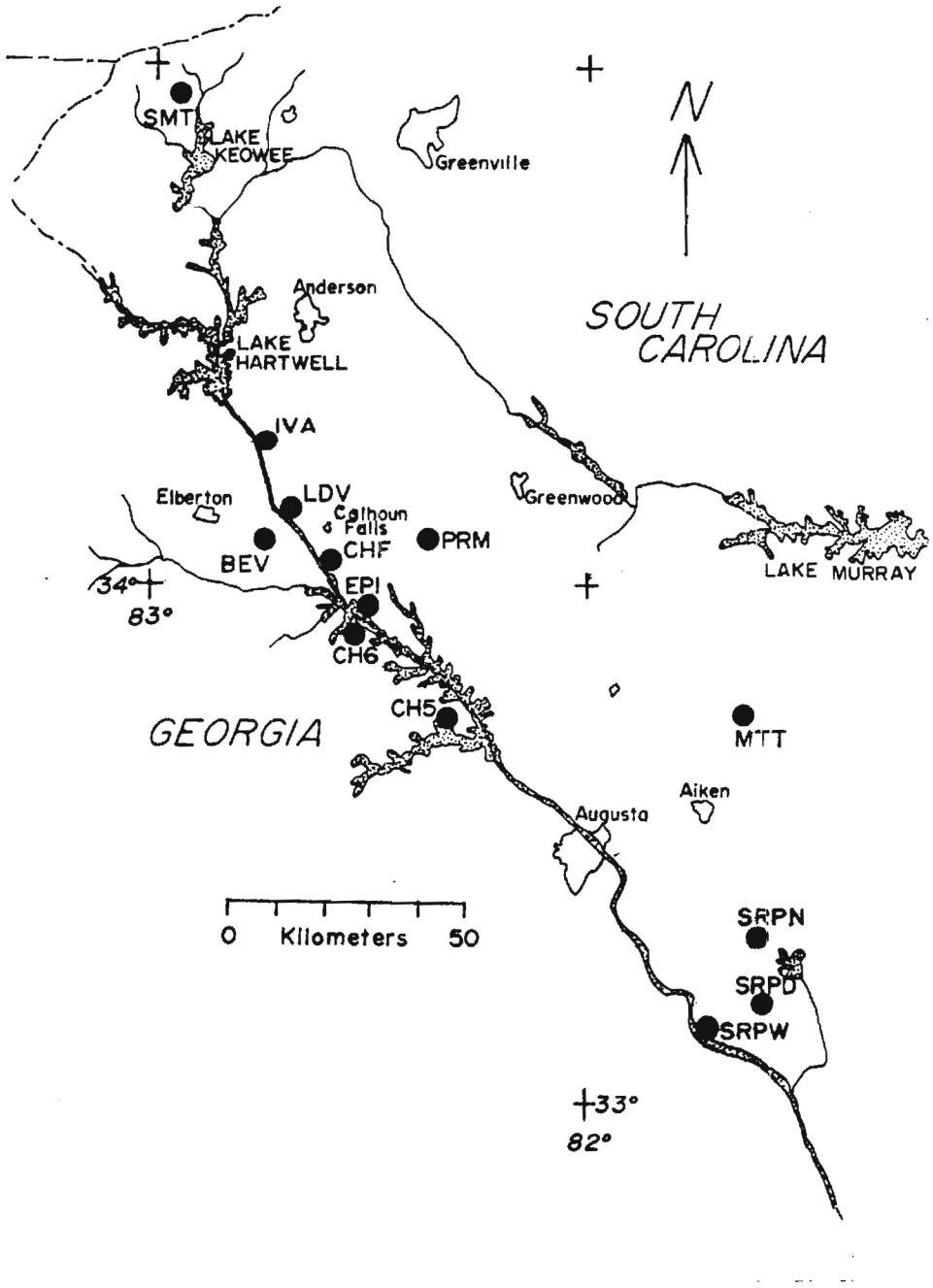

Figure 2. Map of station locations for the Richard B. Russell seismic net.

Instrument Systems

Stations IVA, BEV, and LDV consist of a Kinemetrics 1.0 Hz Ranger Seismometer, Teledyne, Geotech 42.50 seismic amplifier and 46.22 VCO. Solar cells are used to charge a 12 volt lead-acid battery which powers the equipment and a Repco RF transmitter. The equipment is housed in a cinder block vault covered with an iron cover. The solar panel and transmitting antennae are mounted on a 15 meter tower adjacent to the vault.

Station CHF and the three standby stations consist of a Mark Products 1.0 Hz geophone and Georgia Tech designed amplifier-VCO housed in 4.0-inch PVC pipe. The system is designed to run six months to one year on lantern batteries.

Portable High-Frequency Recorders

The portable magnetic tape seismic recorder is designed as an inexpensive means of recording blast and aftershock data in the Piedmont, where high-frequency data are not attenuated by distance or losey material. The sensors are 20 Hz exploration type geophones. The seismic signals are amplified and recorded directly on a portable tape recorder. Seismic data in frequencies from 40 to 300 Hz can be recorded. Time signals from a WWV receiver are recorded in the 800 to 1500 Hz range so that the second and minute signals can be recovered by narrow band filtering of the recorded seismic and time signal. A digital alarm clock is used to turn the recorder on and off at preset times for 90 minute recording periods. The system provides 38 dB of dynamic range at 250 Hz and a timing precision of 0.005 to 0.001 seconds.

COMPOSITE REFRACTION LINE

A refraction line was completed in the summer of 1984 to determine seismic velocity in the crystalline basement of the Piedmont Province. The line was run in the vicinity of the Richard B. Russell and Clarks Hill Reservoirs in order to provide constraints on the velocity structure in the location of induced earthquakes. The area of the refraction line is a 70 km wide zone which runs along the Savannah River in Georgia and South Carolina from just north of the Hartwell Reservoir to just south of the Clarks Hill Reservoir. The seismic sources used in this study were explosions from several rock quarries within the zone of the refraction line. The recording sites consisted of the four permanent stations in the Richard B. Russell Reservoir area and three stations to the southeast in the Clarks Hill Reservoir vicinity. Event-triggered digital and analog records were used in the construction of the travel time curve. The refraction line extended a total distance of 95 km.

The first arrivals of the seismic phases were used to construct the travel time curve (see Figure 3). A least squares estimate of the velocity gives 6.05 km/s for the P-wave. The corresponding S-wave velocity is 3.3 km/s. The P-wave velocity is nearly identical to the

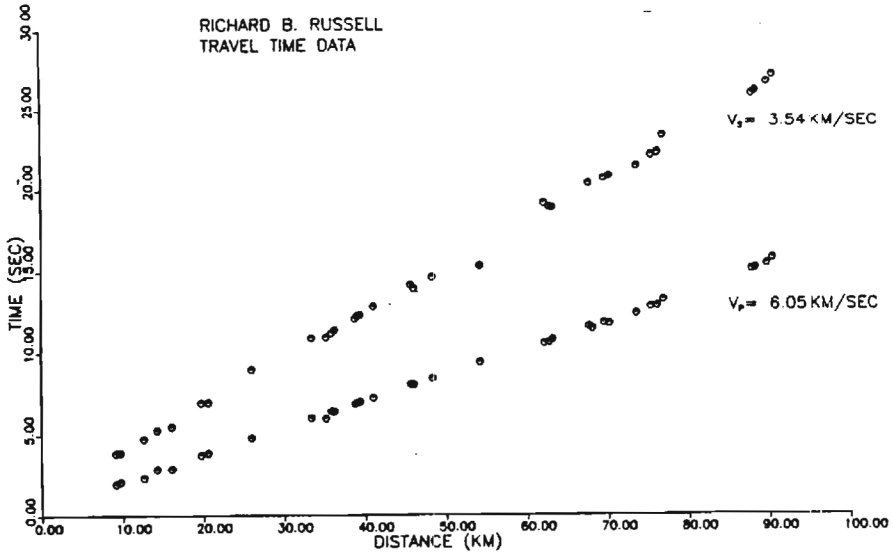

Figure 3. Travel times of P and S waves in the Richard B. Russell and Clarks Hill Reservoir areas.

6.05 km/s velocity obtained by Kean and Long (1980) in a northeast-southwest direction. In contrast to the results of Dorman (1972), the two perpendicular refraction lines through the Clarks Hill and Richard B. Russell Reservoir areas do not indicate velocity anisotropy in the Georgia or South Carolina Piedmont.

DETAILED MONITORING

Objective of Detailed Monitoring

The objective of the detailed monitoring was to obtain a set of unique data which could be used to study, in detail and with precision, at least one sub-area of induced seismicity. The early deployment of the high-frequency systems was desired to allow observation of the initiation and development of a zone of induced earthquakes. Hence, the hope was to track the penetration of earthquake inducing forces into the fractures adjoining the reservoir. By placing many stations very close together (250 to 500 meters), the resulting data set would allow precise determination of depth and focal mechanism. The spectral data would allow measurements of stress drops.

The determination of depth of focus is one of the unique problems of induced seismicity, particularly in the southeastern United States. Most previous studies have placed the recording sites two or more kilometers apart. However, for many induced events, the depth of focus can be less than 0.5 km, and such shallow depths require stations no more than 0.25 km apart if the depth is to be determined by more than two nearby stations. Depth-of-focus is a critical parameter in understanding stress orientation and magnitude since inhomogeneities can affect stress direction, and the maximum allowable stress increases with depth. With depth well defined, these data will allow determination of spectral content (hence seismic moment, fault radius, and stress drop) and focal mechanisms of single events as a function of depth. Knowing the average or maximum stress drop and its direction with respect to depth and time could prove important in understanding the nature of ambient stress and its perturbation by changes in fluid pressure with in the rock. Should we identify induced seismicity, portable systems are ready to be placed in the field.

Objective of Spectral Analysis

The objective of the spectral analysis was to observe the variation of the shape of the source displacement spectra with depth. A systematic change in spectra, most likely in the high-frequency content, might lead to a detection of the maximum depth for seismic activity in reservoir induced sequences. This maximum depth could then be used to limit the maximum earthquake that might eventually be induced at a reservoir.

In his Masters Thesis (Appendix I) Jeff Wilson examined the slope of the displacement spectra above the corner frequency. The spectral

slope is expected to decrease (that is, increase the proportionate amount of high-frequency spectral content) as the depth of focus increases for both naturally occurring and reservoir induced earthquakes. In the case of earthquakes associated with fluid communication from a reservoir, the depth at which the decay rate decreases to the inverse square of frequency may be the maximum depth to which the diffusion of water is increasing the pore pressure to trigger earthquakes. For naturally occurring and reservoir induced earthquakes, this may be the maximum depth to which fluid can lubricate the fault zone because of the hydrostatic and compressive stress environment.

The digitally recorded data set consists of 70 events recorded at Monticello Reservoir, South Carolina, and 35 events recorded at Mammoth Lakes, California. Particle motions are used to determine the angle of emergence. P- and S-wave spectra are computed from trace displacement in the direction of motion. Source displacement spectral parameters are analyzed using Brune's dislocation model. Depth-of-focus is determined by standard location procedures at Mammoth Lakes and by using S-P time to project distance along the ray path at the Monticello Reservoir.

The relationship between source depth and spectral slope could not be observed in data from Monticello Reservoir. This may be a consequence of the narrow range of source depths since a distance criterion is used in the selection of events. This is necessary to reduce the amount of time for refraction so that single-station location techniques cn be used. The lack of events over a wide range of depths, however, may indicate that events in only one isolated zone were triggered during the recording period.

Spectral slope and source depth are negatively correlated for events at Mammoth Lakes. This may indicate that slip occurs along lubricated surfaces for shallower events. It may also indicate that at greater depths there are large discontinuities in rupture velocity or that there are increases in the density and strength of fault plane barriers.

There is positive correlation between changes in spectral slope and corner frequency which may indicate the relative separation of fault plane barriers. Also, the number of fault plane barriers may be related to the source dimension.

For the most part, corner frequency and source depth are unrelated at both of the study areas. The narrow range of source depths may again be a factor in the Monticello results.

CONCLUSIONS

The first six months and up to 30 meters of water impounded at the Richard B. Russell Dam failed to trigger an observable sequence of earthquakes.

The comparisons between induced seismicity and geology above indicate a preference of induced seismicity to ocur in granite gneisses. This term is probably applied to units in which the foliation is poorly developed or discontinuous, as best described for the Winnsboro gneissic complex at the Monticello Reservoir. None of the observed sequences of induced seismicity appears to be located in predominantly mafic rock units or in the larger homogeneous granites.

The P-wave velocity in the northwest-southeast direction is nearly identical to the 6.05 km/s velocity obtained by Kean and Long (1980) in a northeast-southwest direction. In contrast to the results of Dorman (1973), the two perpendicular refraction lines through the Clarks Hill and Richard B. Russell Reservoir areas do not indicate velocity anisotropy in the Georgia or South Carolina Piedmont.

Spectral slope and source depth are negatively correlated for events an Mammoth Lakes. This may indicate that slip occurs along lubricated surfaces for shallower events. It may also indicate that at greater depths there are large discontinuities in rupture velocity or that there are increases in the density and strength of fault-plane barriers.

RECOMMENDATIONS

The association between granite gneiss and induced earthquakes should be examined for all Piedmont earthquakes. This would require more precise location capability for Piedmont earthquakes and uniform geologic mapping for all seismic areas.

Only the recording of high-frequency digital or analog data with sufficient precision to locate the small shallow induced earthquakes will eventually reveal the details of the initiation of induced seismicity and the complexities of a possibly complex ambient stress.

REFERENCES

Dorman, LeRoy M. (1972). Seismic crustal anisotropy in northern Georgia, Bull. Seism. Soc. Am., 1, pp. 35-45.

Georgia Geological Survey (1976). Geologic map of Georgia, scale 1:500,000.

Higgins, Michael W., Robert L. Atkins, Thomas J. Crawford, Ralph F. Crawford, III, and Robert B. Cook (1984). A brief excursion through two thrust stacks that comprise most of the crystalline terrane of Georgia and Alabama, Guidebook, 19th Annual Field Trip, Georgia Geological Society, 67 p.

Kean,A. E., and L. T. Long (1980). A seismic refraction line along the axis of the Southern Piedmont and crustal thicknesses in the southeastern United States, Earthquake Notes, 51:4, 1-13.

Secor, Donald T., Jr., Lawrence S. Peck, David M. Pitcher, David C. Prowell, David H. Simpson, William A. Smith, and Arthur W. Snoke (1982). Geology of the area of induced seismic activity at Monticello Reservoir, South Carolina, J. Geophys. Res., 87, No. B8, pp. 6945-6957.

Talwani, Pradeep (1979). Stress distribution near Lake Jocassee, South Carolina, Pure and Applied Geophysics, 115, No. 1/2, pp. 275-281.

Zoback, M. D., and S. Hickman (1982). In situ study of the physical mechanisms controlling induced seismicity at Monticello Reservoir, South Carolina, J. Geophys. Res., 87, No. B8,